SmartCOS - Insight from Across the United States

Semester 1 Update: December, 2019

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Acknowledgments

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Project Introduction and Background

The City of Colorado Springs (the City) has strategic goals including promoting job creation, investing in infrastructure, building community and collaborative relationships, and excelling in providing services to residents. In support of these goals, the City's Office of Innovation– in partnership with Colorado Springs Utilities – has developed a program called SmartCOS, which utilizes advanced technologies to improve public service and solve issues facing the City. Simultaneously, the City's Economic Development Division (ED) is working to attract new businesses and help existing businesses expand in federal Qualified Opportunity Zones (OZ). This report provides a body of well-researched insight into how other communities across the United States have leveraged advanced technology and developed partnerships among municipalities, higher education institutions, and private sector companies – including startups – to achieve similar goals. It also highlights relevant next steps for the City to develop similar partnerships to advance SmartCOS initiatives.

This report was produced by a team of undergraduate students from Colorado Springs-area colleges. The project was facilitated by the Quad Innovation Partnership, a joint initiative of Colorado College, Pikes Peak Community College, University of Colorado Colorado Springs and the US Air Force Academy that conducts scope-based research projects for companies and organizations in the Pikes Peak region. Students from all four Quad institutions participated in the research. The project was advised by a committee of partner faculty.

The full scope of this project requires two semesters' of study. This report details the findings of the first semester. The semester focused on first researching and understanding Smart Community efforts and Smart Community partnerships in relevant cities across the United States and then applying key insights from that research to Colorado Springs. Subsequent reports will continue the work of applying key insights in order to develop recommendations for partnership development and measurement of the impact of SmartCOS initiatives.

Defining a Smart Community

Broadly defined, Smart Communities generate economic opportunity and improve resident quality of life through the use of advanced technology. Some Smart Community projects focus on massive, big picture or strategic challenges like sustainability or transportation systems; others are targeted at specific issues like trash collection or internet speeds. Though what constitutes a "Smart Community" is broad, each community pursuing "smart" status has its own specific definition, detailed goals, and planned action items.

In Colorado Springs, specifically, the SmartCOS initiative is focused on a series of complementary concepts that align with the City's mission and core values. SmartCOS was developed through a collaboration between the City, Colorado Springs Utilities, community stakeholders, and Panasonic's CityNOW team. Originally, 11 smart concepts were identified through Panasonic's Smart City Pillar Process. As implementation work has gotten underway, there has been positive evolution of those concepts.

Table 1 - SmartCOS Concepts

SmartCOS Concept	Description
Advanced Metering Infrastructure	Integrated system of smart meters, communications networks and data management systems.
Connected Vehicle Platform	Enabling the adoption of Connected vehicles in urban environment.
Microgrids	Integrated power delivery system.
Enhanced Engagement	Publish city-owned data & modernize citizen request process.
Smart Building Management System	Making buildings more efficient through automation and integration.
Smart Kiosks	Integrating wayfinding and other user-friendly information in the downtown core.
Smart Parking	Improving the efficiency and customer interaction with parking.
Smart Payment Solutions	Payment integration system for various modes of transportation.
Smart Security systems	Adopting cutting edge technologies for the benefit of public safety.
Smart Streetlights	Converting existing streetlight infrastructure with sensor-capable LED lighting.
Smart Transportation	Integrating smart technologies into long term transportation planning.

From: City of Colorado Springs & Colorado Springs Utilities Smart City Strategy – November, 2018

Methodology

Semester 1:
1. Understanding Smart Communities/Identifying Smart Communities in US
    a. General information gathering
2. Focus on cities relevant to Colorado Springs
    a. Focused and detailed information gathering
    b. Interviews with key stakeholders in those communities
3. Research Analysis
    a. Narrowing from 12 initiatives to increase depth of insight
    b. "Pattern" identification
    c. Best practices and lessons learned
4. Application to Colorado Springs
    a. Preliminary "survey" of relevant next steps.

The research began by anchoring a common understanding of what constitutes a Smart Community partnership relevant to this research. Ultimately, a relevant partnership was defined as including municipal government, higher education, and private sector partners. Though the

research scope provided by the City identified startup companies as the private sector focus, the study cast a wide net of private sector partners to deepen understanding.

Then, 12 robust and prominent Smart Community initiatives were identified for focused research and analysis. Initiatives were limited to those in the United States to minimize the impact of alternative national government structures. Generally, four considerations were used to select initiatives: **1)** prominence of the Smart Community project, **2)** community population and geographic size **3)** role of higher education in the project **4)** type and characteristics of municipal infrastructure involved in the project (for example, streetlights, traffic control, etc.).

Some initiatives were chosen on the basis of similarity to Colorado Springs on one or more of the criteria; others were chosen on the basis of dissimilarity to provide comprehensive understanding. The initiatives prioritized in this research were:

Table 2 - Selected Smart Community Initiatives

City-based Initiatives	University-based Initiatives	Other Initiatives
Atlanta, GA	Denver University	Metrolab Network
Austin, TX	Purdue U. Research Park	
Columbus, OH	U. Mich MTEST Facility	
Pittsburgh, PA	U. Mich Urban Collaboratory	
Providence, RI	Urban Future Labs (NYU, Columbia)	
San Diego, CA		

Each initiative was aligned with at least some of the stated SmartCOS project areas:

Table 3 - Alignment with SmartCOS Project Areas

SmartCOS concept:	Advanced Metering Infrastructure	Connected Vehicle Platform	Microgrids	Enhanced Engagement	Smart Building Management	Smart Kiosks	Smart Parking	Smart Payment Solutions	Smart Security Systems	Smart Street Lights	Smart Transportation
U. Mich	x	x	x	x	x	x	x	x	x	x	x
Denver U.			x	x						x	
Austin	x	x				x	x			x	
MetroLab	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Pittsburgh	x	x	x	x		x	x			x	x
Columbus		x		x		x					x
Providence		x		x			x		x	x	x
San Diego		x								x	
UFL (NYU)					x						
Atlanta											x

Research on each initiative began with a comprehensive review of published information including official reports and documentation, private/public research reports, meeting records,

marketing and advertising material, published media, and others as available. Outreach was then initiated to key leadership offices for each initiative. Informational interviews were conducted via phone and interview to capture lived experience and compliment published information. Response rates and engagement was high for almost every initiative at the Executive Director, Director, Project Manager and Program Manager level.

Collected information was analyzed and consolidated. Patterns among all twelve initiatives were identified related to City priorities, including initiative starting point/catalyst, funding structures, communication strategies, impact measurement, partner roles, and overall objectives. Five initiatives were found to have the most robust relevance to Colorado Springs for positive emulation.

- Pittsburgh, PA
- Columbus, OH
- Urban Future Labs
- University of Michigan

Other initiatives offer insight into key lessons that Colorado Springs can use to maximize impact overall.

Finally, the key insights from all of the communities researched were applied to the City and the Colorado Springs community to identify tactical next steps for developing a local partnership. This application is only preliminary; it will serve as the starting point for the second semester of this research project.

Report Organization

This report is organized to maximize the accessibility of insights gleaned through the research. Emphasis has been placed on communicating the key findings, patterns, and lessons from the complete set of researched initiatives in the body of the report. These findings are anchored in examples from individual initiatives. Detailed overviews of each individual initiative are provided in the appendix.

Key findings are also applied to Colorado Springs holistically in the preliminary recommendations section. Lessons from individual initiatives were included in the analysis to arrive at these recommendations; however, overarching patterns from multiple initiatives held greater weight than any single example. Much of the application of key insights to the City and community will be detailed in subsequent reporting after the second semester of research has concluded.

Key Findings: Trends and Patterns

Identifying a "Successful" Partnership or Initiative

For the purposes of this analysis, a "successful" initiative is one that has achieved or is achieving widespread implementation of identified actions necessary for reaching defined goals, and documentation that such implementation is meeting or progressing towards those defined goals. Analysis on the basis of this recommendation showed that successful Smart Community partnerships tend to display three primary characteristics:

1. <u>Willing, Mutually-Focused Industry and Higher Education Partners(s)</u>
   Active involvement of a partner from the private sector or higher education with fundamental, strategic alignment with Smart Community project objectives

2. <u>Diverse Funding Array</u>
   Multiple sources of project/partnership funding aligned with strategic objectives and diversity of involved partners

3. <u>Unique, Focused Projects</u>
   Specific, actionable, and achievable objectives that balance big picture strategy with tactical goals for feasible progress

Willing, Mutually-Focused Industry and/or Higher Education Partner(s)
Successful initiatives involve industry and/or higher education partners that have core, strategic competencies fundamentally aligned with the Smart Community project or initiative. Additionally, these partners must express willingness and commitment to long-term involvement. This kind of partnership epitomizes a "win-win."

This study identified several communities where partner involvement was reluctant or absent due to an imbalance in the returns delivered to each partner. In some instances, private sector "partners" were actually vendors – only committed to the initiative insofar as it represented a sales opportunity for existing products or services. True partners from industry were found to be aligned on a strategic level, typically indicated by relevant research and development (R&D) activity occurring within the community where the initiative was based. On the higher education side of these partnerships, poorer results were seen when the Smart Community partnership was not relevant to an existing or priority research/academic cluster. Colleges and universities with strategic priorities and research focuses relevant to the Smart Community work tended to express deeper commitment, like dedicating labs or pursuing research funding for the work.

Cultivating willing partners starts with strategic alignment. This alignment can be high level – simply sharing a goal of "economic development" – is a viable starting point. However, focusing this high level alignment into more specific shared goals is better. For example, a goal like "[to] provide a test bed for automotive companies to test state of the art of technology," can align a

municipality (e.g. Pittsburgh), a university with existing excellence in automotive technology and research (e.g. Carnegie Mellon) and transportation companies interested in commercializing associated research (e.g. Uber). This kind of alignment creates real reason for all partners to share in the risks, rewards and resources associated with a Smart Community initiative – including contributing jointly to funding requirements.

Diverse Funding Array

Successful initiatives are resourced through numerous, diverse funding sources. The most successful initiatives layered federal infrastructure grants, dedicated research funding sources, private investment, and also municipal funds. Successful initiatives were often developed to match available funding as opposed to trying to convince funders to dedicate new programs or funding streams to match the initiative.

No successful initiative researched through this study resourced the project through exclusively one funding source. Even one of the most successful initiatives ran into trouble when one of its sub-projects, the installation of smart streetlights, attempted implementation with funding exclusively from the municipal budget.

In many ways, diverse funding emerges from diverse partners. In three of the most successful case studies included in this study, funding was not the starting point of the initiative. Instead, private sector and higher education partners were cultivated first to identify alignment. As potential partners and areas of alignment emerged, each partner was able to identify sources of potentially available funds targeted at the common goal. The parameters of that funding then further refined the parameters of the partnership through an iterative process until partners, funders and community goals were all well aligned.

The Smart33 corridor project in Columbus is one of the most successful projects identified by this study. It is also both an exception to the general rule that funding follows initial partner identification and an example of how funding diversity matches partner diversity. The City of Columbus secured a federal grant at the onset of the project, before much partner development had occurred. The grant, though, encouraged additional matching funds from other sources, incentivizing Columbus to engage in the iterative process described above of identifying partners, soliciting ideas of suitable funds, tailoring the project to the funds and so-on.

Unique, Focused Projects

While all of the Smart Community initiatives and partnerships examined in this research proclaimed lofty, big picture goals as the ultimate purpose of the work, the successful initiatives solidified a specific scope of work or collaboration between partners and stakeholders that defined how to achieve a lofty vision through specific, focused actions. Additionally, successful communities had tailored this specificity to the unique assets, attributes, and opportunities of the region.

To explain the connection between big picture and tactical goals, a comparison to nature is particularly helpful: in the "ecosystem" of a Smart Community, the tactical goals can be thought

of as seeds. The soil contains the unique aspects of the community itself; the right seeds must be selected in order to germinate in the specific kind of soil. The project or work itself is the plant that germinates from the seed. The oxygen released by the plant once it reaches maturity is the big picture goal or vision articulated as part of the project.
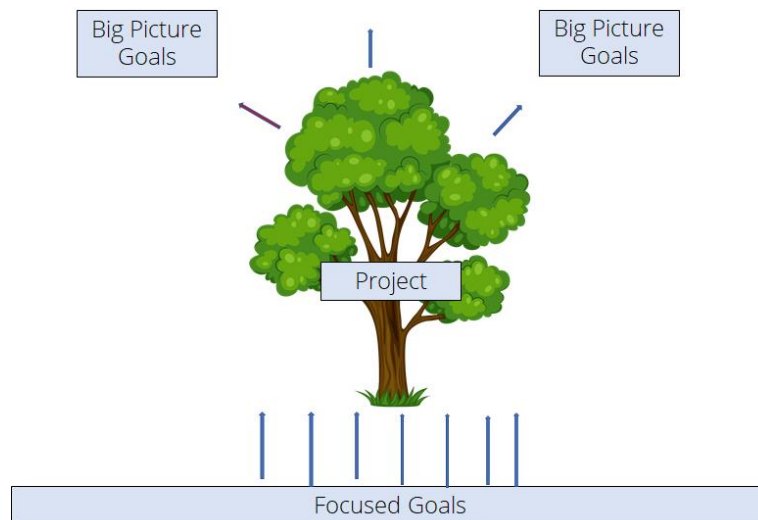
Figure 1 - Smart Community Ecosystem

That is to say, achieving the big picture vision (like overall economic growth, establishing a community's position at the "forefront" of an industry or trend, or attracting a specific industry leader like Uber or Google) is achieved by the environment created from lots of smaller projects with focused goals. Sufficient oxygen is not released by one plant or a single direct action, but by the cultivation of environment where many projects can grow, flourish and achieve impact.

Success, Contextualized

These three features can be interpreted in different ways and express themselves differently in each community studied. They are complimentary, impact each other, and often evolve through slow iteration through multiple concepts and conversations. However, all three of these success indicators indicate a deep understanding of and connection to the specific aspects of a project or initiative's region. The most successful initiatives examined in this study exemplified all three indicators by leveraging existing industries, resources, research and strengths.

Successful Initiatives: Patterns to Understand and (Possibly) Emulate

This section details the key findings from the four initiatives displaying the highest indications of success included in this research:

City-Led Initiatives	University-Led Initiatives
• Pittsburgh, PA	• U. Michigan (both initiatives)
• Columbus, OH	• Urban Future Labs (NYU)

Overview of "Successful" Case Studies: Big Goals Through Mutual Focus

Though each of the most successful initiatives is organized differently, all displayed focused goals that were further refined into attainable, actionable projects. Three initiatives are focused on the same area – transportation – while the other, Urban Future Labs, is focused on sustainability.

Smart 33 Mobility Corridor: Columbus, OH   Focus: Transportation Technology

The Smart33 Mobility Corridor project in Columbus, OH provides an example of a project with a focused scope, but far-reaching outcomes. The Smart33 Mobility Corridor was developed after the Columbus city government was awarded a multi-million-dollar grant from the US Department of Transportation (DOT). This grant was awarded largely because of the region's preexisting robust automotive economic sector and the municipality's commitment to further strengthening that position.

The Smart33 Mobility Corridor is intended to be a test bed for new transportation technology. It is intended to spur growth within the automotive industry locally. By transforming roadways in the corridor to a living lab for technological development, the region's hope is to achieve broad growth and advancement.

The Smart 33 Corridor includes many specific sub projects, coordinated by a Council of Governments. The Council is comprised of municipal departments. After securing the DOT grant, the Council of Governments (CoG) established Working Groups - multidisciplinary groups of industry partners, researchers from the Ohio State University, municipal departments and national government research labs that focus on specific projects under the broader Smart 33 initiative. (Additional information: Appendix — Columbus). The most prominent of these projects was the installation of a 39-mile run of fiber optic cable to support economic growth and development of autonomous vehicle technology. This project alone contributed to the involvement of companies like Honda, Denso and Uber. In this way, Columbus provides an excellent example of how to achieve a broad objective by focusing on obtainable projects well aligned with pre-existing local strengths and capacities.

Metro21 Lab: Pittsburgh, PA   Focus: Transportation Technology

Much like Columbus, Pittsburgh is a city focused on Smart Community-related issues particularly relevant to the region's economic and research strengths. Metro21 Lab, centered at Carnegie Mellon University (CMU), is a partnership between CMU, the City of Pittsburgh and a few other ancillary players to apply academic research to municipal issues. CMU has been a

national leader in technology research for decades; the first ever automated car was developed by CMU researchers with funding from the Department of Defense in the 1990s. Now, some $1 billion worth of technology research occurs on campus annually.

The Metro21 Lab has a broad goal of applying and testing research to solve community issues, making the community more innovative overall, and to generate economic growth. Specific initiatives are developed to achieve more targeted outcomes. Within each initiative, there are even further targeted projects. Sometimes those projects are the result of a City-identified issue that spurs new research. Typically, though, pre-existing research is matched with a community need through an iterative process. "Surtrac", for example, is an effort to focus on transportation efficiency. Through Surtrac, a CMU researcher developed an algorithm to maximize the efficiency of traffic light cycles that was ultimately deployed to City signals through the lab. The light cycle algorithm represented a community application of pre-existing research activity on efficiency.

Metro21 Lab has had a demonstrable effect on the region's economy. Google and Uber are two major technology companies expanding their R&D efforts in the Pittsburgh region in part because of Metro21. Those big wins were accomplished by steady, intentional progress through targeted projects.

The most important feature of the Metro21 Lab is that it is collaborative and ongoing. Karen Lightman, Executive Director of the Metro21 Lab, said that she is in constant communication with the City of Pittsburgh's Innovation and Performance Department. Rather than creating a new department, Karen's role is to liaison between the organizations. Her explicit purpose is to ensure that CMU research is related to and actually deployable in Pittsburgh. Below is a schematic of the Metro21 collaboration structure, which emphasizes collaboration. Research work is collected by CMU deans and sent to Karen's office; city needs are captured by city departments and workers and sent to Karen's office through the Department of Innovation and the Mayor's office. Karen then matches needs and resources, to the benefit of the region.
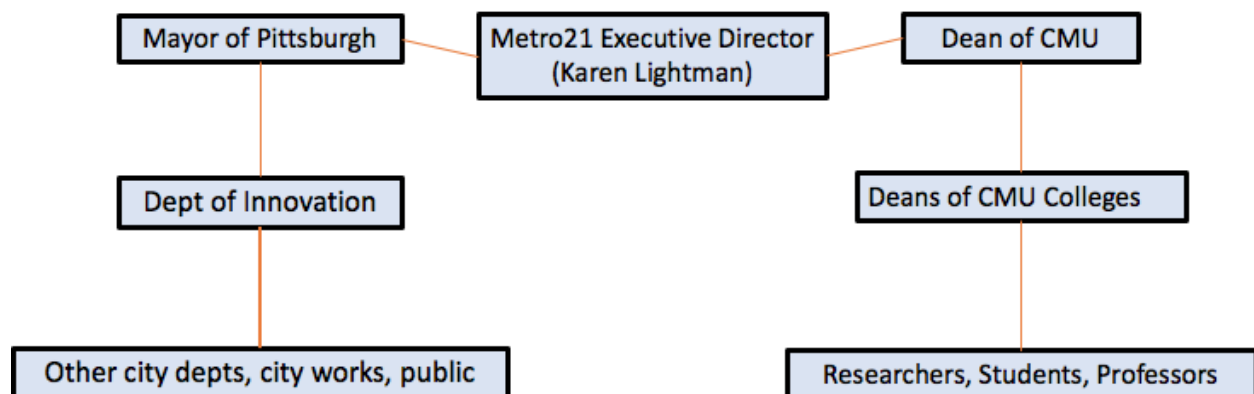
Metro21 Lab structure:

Figure 2 - Metro21 Organizational Structure

MCity Test Facility: University of Michigan   Focus: Transportation Technology
Urban Collaboratory: **University of Michigan**   Focus: Transportation Technology

The MCity Test Facility at the University of Michigan has also achieved notable success related to its parallel focus on automotive and transportation technology. Michigan has long been home of many major car manufacturers; the overall focus of the initiative leverages that historic strength. However, as is commonly known, the Detroit-based automotive powerhouses of the 20th century have been disrupted. Michigan cities have been hit hard by the changing landscape. MCity was launched in response to accelerate the implementation of advanced technologies related to transportation to solve specific needs of nearby communities and to spur economic opportunity. The facility comprises a 30+ acre test track for new automotive testing, supporting partnerships with the private sector focused on the real world needs of partner municipalities.

Spurred, in part, by the MCity facility, the Urban Collaboratory (UC) is not a partnership between a single city and its respective higher education institutions. UC facilitates many partnerships between the University of Michigan and municipalities in Michigan, across the United States and in near-international locations related to transportation.

UC research is sourced from specific Smart Community efforts in partner communities. Research capabilities are developed, organized and activated around the needs of those efforts. Because of its geographic reach, it is difficult to determine the overall success or level of implementation the UC has catalyzed. Much of the research published and/or promoted by the Collaboratory itself is theoretical – useful for guiding implementation but not always the result of an implementation effort. Though the level of implementation is difficult to discern, the Facility is nonetheless notable in the context of Colorado Springs' Smart Community efforts because of the scale of the effort, organized into specific, focused projects.

Urban Future Labs: New York, NY   Focus: Clean Tech/Sustainability

Urban Future Lab (UFL) started in 2013 as a partnership between New York City's Economic Development Corporation, the NYU Tandon School of Engineering, and Columbia University. The partnership focuses specifically on clean technology to accelerate the adoption and commercialization of new technologies for environmental sustainability. Many Smart Community partnerships examined through this study had a similar clean/green focus, however UFL was the most successful.

Like the Smart 33 Corridor, Metro21 Lab and MCity Test Facility, the technology deployed through UFL is intended to catalyze economic growth and job creation through impacting its target sector. UFL also achieves its broad objectives through more targeted initiatives and specific projects. For example, PowerBridgeNY, ACRE and Clean Start Diploma are all initiatives within UFL that house a variety of specific projects to encourage business investment, foster startup growth and develop a skilled workforce.

Notably, UFL has catalyzed significant startup activity. Over 50 startups have graduated from ACRE, the UFL incubator, since its inception in 2009. 88 percent are still in business, contributing significantly to the area economy.

How Successful Partnerships Started

In all four of these "most successful" partnerships, the starting point was relationships between municipalities and their respective higher education institutions. This pattern was also present in the majority of other partnerships analyzed in this study. Sometimes these relationships were formal; other times they were informal relationships between individual offices or staff members.

In Pittsburgh and New York City, these relationships allowed for the mutual exploration of priorities and complimentary capabilities. In Columbus, the DOT grant was secured before any partnership with the Ohio State University was formalized, but positive relationships and informal alignment preceded the grant application. In Michigan, these relationships provided an opportunity for the University to dedicate its own resources as an investment in the potential of scaling Smart Community partnership research.

From those initial relationships, development processes diverged. Pittsburgh progressed into scanning of existing research projects in the region and matching to city needs, since CMU had such strong pre-existing research that was relevant, but not necessarily Pittsburgh-specific. In New York, the preliminary relationships between municipal government, NYU, and Columbia was activated around sustainability in the wake of the 2008 recession; each school had some relevant research, but perhaps more importantly, sustainability was an emerging sector at that time and all partners saw a new opportunity to establish leadership. In Columbus, informal relationships informed the DOT grant, which then formalized relationships, further engaged private sector partners and activated work at a significant scale.

Additionally, in all of these initiatives, alignment of the overall focus with widely held community strengths and priorities supported strong starts. The automotive history of Michigan and strong sector presence in Columbus stewarded popular support. New York's commitment to environmental sustainability is a priority held by a majority of its residents. The Pittsburgh community takes pride in CMU's transportation research. This kind of popular alignment is always helpful in stewarding work that involves the public sector and Smart Community initiatives are no exception.

Partnering Entities: Organization Types and Roles

As previously mentioned, the most successful efforts studied through this research involved municipalities and higher education institutions. The specific departments involved within each of those entities varied – in Pittsburgh, partnership work includes the Mayor's office while in others work is centralized in specific departments. The municipal and higher education partnership elements were identified, developed and formalized through an iterative process that,

as it progressed, engaged other stakeholders, funding considerations, and every other strategic and tactical component of the project.

From the initial alignment of municipal and higher education, private sector partners were then identified and included. There appears to be no common order or procedure to developing the private sector components; however, most private sector partnerships were made possible by higher education and municipal governments being able to offer area companies something they couldn't do on their own: the opportunity to advance R&D through using university research capabilities and municipal infrastructure as a "living lab" of sorts.

An important distinction that became clear through this research is between a **private sector partner** and a **private sector vendor**. Many communities engaged the private sector under the label of "partnership" in a capacity that was limited to simply contractual sales of services or products. In some cases, private sector vendors were hired to develop implementation strategies or to do strategic development for a university-municipal partnership. In others, they were contracted to supply specific components for a project. While this kind of vendor relationship yields mutual value in a Smart Community initiative, it falls short of the mutual contributions and value of the true private sector partnerships in these "most successful" cities. These partners all had a vested interest in the Smart Community work beyond a one time or multi-year transaction. They are true collaborators in the research, development, testing and eventual commercialization of new technologies and capabilities. The value to the private sector actor in these instances is the strategic growth of their entire business portfolio; not simply closing a "deal".

The most successful initiatives focused on private sector partnership from sectors or individual companies that already comprised strong components of the area ecosystem. Suitable private sector partners often – but not always – had relevant, significant, and pre-existing R&D work in the region or with one of the other partners in the initiative. (See Appendix for more detailed insight).

- In Pittsburgh, CMU had a pre-existing collaborative research lab with General Motors (GM); because of their preexisting R&D at that lab and relationship with CMU, GM became an early partner in Metro21. Only much later did Uber become involved – partially as a result of Metro21's success. Uber's partnership was solidified by their development of the RiverFront Testing Facility, a massive R&D facility for autonomous vehicles.
- Efforts in Michigan and Columbus similarly were able to include the private sector in Smart33, MCity and UC as a result of the significant, nearby R&D activities of major companies. Honda and OSU, for example, also had previously collaborated on research and Honda's involvement in Smart33 arose from that previous relationship.
- UFL is the only initiative with significant private sector startup involvement. That is because UFL was developed specifically to commercialize technology. A startup incubator is a key component of UFL. Notably, few startups are UFL partners in the same way that Honda is to the Smart33 Corridor or GM to Metro21. They are the outcome of the partnership, not a major piece of its infrastructure.

Formalizing these relationships is varied. The relationship between CMU and the City of Pittsburgh by way of Memorandum of Understanding (See Attachment for sample MOU). Other efforts used different legal and contractual structures.

Funding

All of the "most successful" initiatives secured substantial amounts of public and private grant funding. While the grants were significant (in terms of size and quantity, depending on the initiative), they were also complimented by a range of other funding sources. The "capital stack" was widely varied from region to region. For example, Columbus's federal grant was complimented by significant business investment. UFL was also funded primarily through a state grant, which was leveraged against local, research and business funding.

Pittsburgh's non-chronological capital stack currently includes:
- $300M business investments (including facilities like Uber's R&D lab)
- $300,000 allocated in municipal funds in 2018 – most for CMU-housed research
- Multi-million dollar USDOT Smart City Challenge Grant
- Various research grants and foundation-sourced research funds

UFL's stack:
- $10M NY State ERDA grant (to Columbia and NYU)
- Corporate Sponsorships from Urban Green Council, Downtown Brooklyn Partnership, National Grid, and many others

Columbus's stack:
- $5.9M USDOT grant
- CoG contributions from municipal funds
- Ohio Department of Transportation percentage match
- Honda 100% match of CoG investment
- $45M from Ohio Governor's Office
- Further $1.4M from association of private sector companies
- $10M from Vulcan, a USDOT partner
- In-kind technology contributions from private sector

Michigan's funding is similarly varied – a combination of public grants, university funding, city funding, public-private R&D initiatives, and foundations (see appendix).

The key insight is that successful initiatives leverage lots of different funding streams. No single funding stream is sufficient. Fortunately, partnerships of diverse, mutually-aligned actors have access to many types of diverse funding and collaborative efforts are frequently seen more favorably by public and private funders.

Including funding considerations early in partnership development does appear important. Interviews with stakeholders in the most successful initiatives all indicated that the iterative process of formalizing the partnership effort included information about available funding

sources and associated parameters early. Often partnership focuses and tactics were refined to better match available opportunities.

Communication Strategies

Any initiative that involves municipal government requires thorough, intentional communication to steward community awareness and protect public trust. Key lessons according to Karen Lightman, Executive Director of Metro21 and Eric Phillips, Economic Development Director of the Marysville-Union County Port Authority:

- Online communication essential – can reach a large audience if intentional
    - Dedicated social media for the project/initiative
        - Use social media as introduction to important issues/context of the project; minimize progress updates in favor of cultivating awareness and understanding of the needs/motivations for the project.
    - Regular inclusion of material from partner entity social channels
    - Target each account to appropriate demographics (Youtube, Snapchat, Instagram for youth; Twitter for young professionals; etc)
    - Podcasts
- Traditional engagement
    - Town Halls and Public Forums
    - Public Meetings
    - Mayor's Roundtable or Industry Associations
    - Earned Media
- Creative engagement
    - "Smart Columbus Experience Center" – facility residents can visit to experience technologies firsthand
    - "Smart Cities Institute Podcast" – hosted by ED of Metro21

In Colorado Springs there are already several social media avenues with a strong online presence — such as the City's Twitter page with 57,000 followers and the 'Behind the Springs' podcast. Leveraging these assets in addition to those included above to cultivate awareness and understanding will help minimize the potential for misinformation and ignorance. By emphasizing that Smart Community projects are led by people with a vested interest in the region, will have direct benefit to area residents, and often generate financial savings for the public sector long term, community support and understanding can be maximized.

Metrics and Indicators of Success

Measuring impact is an important component of Smart Community work everywhere. This section provides examples of how these "most successful" communities are measuring progress and impact. It is not a comprehensive list of all of the outcomes achieved by these projects and initiatives; just examples of the different ways these communities measure what they've achieved.

Columbus: Quantifying Installation and Adoption

Installation of 39 miles of fiber optic along the 33 Corridor in the Columbus region was completed in 2017, with 42 additional miles slated for completion in 2020. With technology provided from industry partners and with the research from OSU and Transportation Research Center, over 1,200 public and private vehicles have been equipped with onboard traffic units. According to Eric Phillips, Executive Director of the Smart33 Corridor, a 60-mile stretch of Interstate 90 has been equipped with short-range digital communications units to track data to help law enforcement and manage roadways during inclement weather conditions.
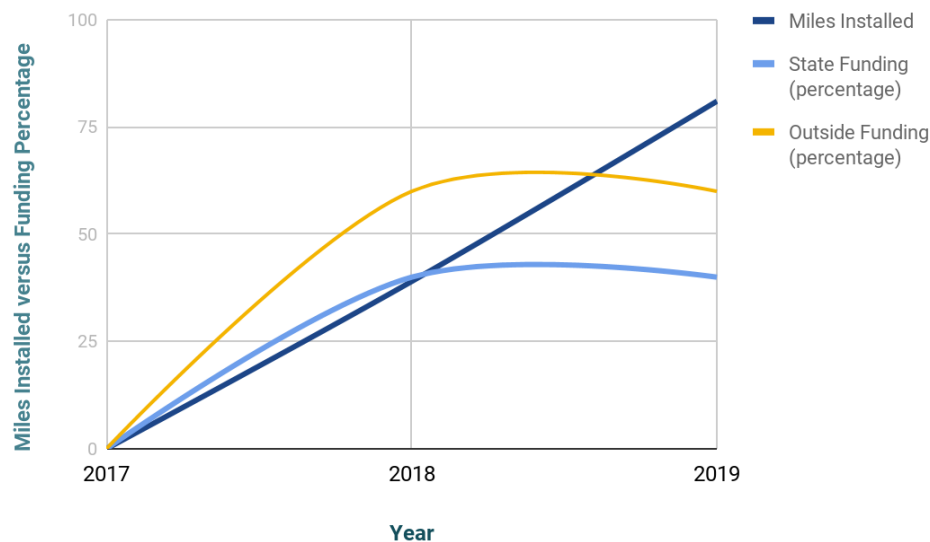
Figure 3 - Smart 33 Corridor Trajectory

Pittsburgh: Quality of Life

In Pittsburgh, Metro21 Lab has been able to improve several aspects of Pittsburgh's quality of life. Using CMU technology and research, algorithms have been implemented to improve the efficiency of trash collection and snow plowing; mapping and data analysis has been used to reduce the incidence of landslides and reduce fire risk in buildings throughout the city; an Independent Systems Operator now manages curb space and reduces crowding (See Appendix — Pittsburgh Metrics). Metro21 publishes raw data, analysis and visualizations (like graphs) for the before/after of all of this work.

New York: Economic Impact

UFL publishes its own impact, including:
- $251M in new economic activity
- 57 companies incubated with 88% survival rate
- $450M capital raised by incubated companies
- More than 530 new jobs created in city limits

Michigan: List of Statistics and Research

Michigan's strategy for communicating their impact is a somewhat disjointed list of facts, figures and ongoing research that are best described as 'interesting and cool'. According to the University, outcomes of the MCity Test Facility, Urban Collaboratory and other Smart Community initiatives include:

- 26.98% increase in controlling flash flood events in cities with combined sewers
- Assessing the impact of autonomous technology on the insurance industry
- Quantifying the impact of autonomous vehicles on motion sickness
- Maximizing fuel economy of heavy highway vehicles through optimizing gear selection and mathematical modelling
- Transportation and vehicle safety
- Real-time operations of autonomous vehicles

Key Takeaways: Successful Communities

The most important features of the Smart Community partnership initiatives in these four regions is their emphasis on utilizing existing resources/strengths of their area and having a scope focused on a specific sector or outcome. Large picture objectives are achieved through tailored goals and targeted projects. Projects are all aligned and eventually, achieve large scale impact; the tactical work comprises a bigger whole.

There is no "right" way to start or specific funding structures that must be followed, but generally partnerships start with relationships between municipalities and higher education first. Those relationships are aligned with area economic strengths. Through an iterative process, private sector partners are included and funding opportunities examined and pursued. Funding is always diverse and varied.

Private sector partners typically already have meaningful, relevant relationships, significant local R&D and a large local footprint. Few startups were seen as fundamental "partners" – they can be outcomes, though. The combination of university research facilities and a "living lab" of municipal infrastructure is compelling to support growth of both large companies and new startups.

Communication and measuring impact are also important. Emphasis should be placed on cultivating awareness of the reasons/motivations for the Smart Community work and proving the benefit to the region.

It may be apparent to the reader that this research only briefly mentions partners with attractive names like Uber, Google or Honda. This is on purpose. While all four of these "most successful" initiatives attracted major companies, those companies were either already deeply invested in the respective community or ultimately attracted after years of focused work eventually created large scale impact. Starting Smart Community partnership development work without an orientation towards those big names is a better and more realistic approach.

Lessons Learned

While some cities had large scale success, as detailed in the sections above, it is important to analyze less successful projects and learn from previous experience. Some of these lessons come from initiatives that are still struggling to get off the ground; others come from the same successful initiatives previously detailed.

It is important to recognize that the referenced examples do not necessarily have less funding, less brain power, less community investment, or even less advance planning. In fact, the only commonalities between these lessons are unfocused goals/objectives (or many tactical projects that did not combine to form a strategic whole), less collaboration, and/or community opposition.

As a matter of courtesy and consideration for the privacy of individuals interviewed, the specific names of these projects have been omitted.

A. One region studied for this project set out to address issues specific to the region. The city government did not contribute financially to the research and the research was funded only through existing university funding. No municipal investment limited the apparent importance of clear communication between city stakeholders and researchers. The results were highly conceptual and theoretical solutions to city issues. The research failed to create any tangible products, technologies, or solutions that the city government could actually use. While the effort did not waste public funds, it set the overall initiative back several steps. This provides a prime example of the pitfalls that can result from **insufficient collaboration, a sole funding source and an unfocused scope.**

B. A different initiative created a plan to deploy an intelligent traffic system on their street light poles. A Fortune 500 company was contracted to develop and implement a deployment plan, which was solely funded with public funds. However, community members expressed concern about how the new technology could diminish privacy. Some members of the community worried that the technology would invade their privacy and insisted that the project be stopped until this city enacted policies to protect their privacy. The project has been stalled for years with no signs of moving forward. This provides a prime example of why **communication and impact measurement** is so important.

C. Another pitfall identified by key officials in one region was the issue of existing infrastructure or lack thereof. In this region, the deployment of smart streetlights was put to a halt when engineers realized that some areas lacked the basic electric infrastructure needed to install the smart streetlight technology. Before the implementation of the smart streetlights could continue, this city had to install the necessary electric infrastructure, costing more money and delaying the timeline of the project. While this particular issue may be specific to the region, the idea of **a project that is fundamentally out of alignment with regional strengths and capabilities** is important. In another city studied, the city government went $1M+ dollars over budget because the Smart Community project was also significantly out of alignment with community capacity, infrastructure and context.

Appendix

COLUMBUS

Methodology/Roadmap:
- By making itself a "test bed" for industry technology, Columbus's strength is their focus on implementation at the local level.
- Local governments in the Columbus, Ohio region work together through a COG to establish Smart Community plans, with monthly public meetings.
  - COG collaborates with Smart Columbus to optimize project impact.
  - Upon the state of Ohio receiving a grant from the U.S. Department of Transportation, the COG established specialized committees to meet weekly and discuss the logistics of project implementation.
- Companies are considered for projects through "Requests for Proposals" (RFP).
- Once the projects are planned, private companies, higher education institutions, and the COG create "working groups" specific to each project.
  - Working groups consist of government departments at both the state and local (vertical and horizontal communication).
  - Working groups integrate offices from Drive Ohio, COG members, and their partners (including OSU), Smart Columbus, and industry partners.
  - Interdepartmental working groups then implement the projects.

History/Origin:
- Strong presence of automotive industries in Columbus region, with OSU's Transportation Research Center established in 1962.
- OSU, Honda partnerships dating back to 1987, with the construction of automotive plant in Ohio.
- Community familiar with existing automotive technology and innovation.

Project: **Smart 33 Corridor**

Purpose:
- Provide a test-bed for new technology; attract business investment in the region; utilize existing industry partnerships and higher-ed research

Key Players:
- COG — City of Dublin, Marysville, Union County in Columbus, Ohio Region.
- COG is the main source of project oversight and implementation. COG meetings are held monthly and open to the public.
- Specialized committees were created within COG to oversee infrastructure, connected vehicles, etc., meeting weekly.
- Committees currently discussing network infrastructure as a part of Phase 2 of implementation of the Smart33 corridor.

- City/regional governments within COG work with Smart Columbus and Drive Ohio/Ohio DOT through "working groups."
- Working groups are interdepartmental industries that focus on projects rather than departmental boundaries.
    - For example, for the implementation of fiber optic cable, engineers, IT, and public works officials across many departments and companies worked together in working groups.
    - Working groups communicate directly with industry partners — Michael Baker is the primary industry contractor, who oversees actual implementation in coordination with working groups.
- State government communicates with regional government as well as companies, providing both vertical and horizontal communication.

Sources of Funding:
- US DOT grand of $5.9 million given to Columbus, OH region and dispersed among COG ("Council of Government") members.
- Ohio DOT matched 20% of COG funding.
- Honda also provided match funding.
    - Honda has significant history in the region. They previously invested in community with Ohio State University Transportation Research Center, as well as having manufacturing in Columbus region.
- Denso (international automotive company with an office located in Dublin, near Columbus), provided $1.4 million grant for the purpose of testing technology. The basic value exchange was that the city government would provide a test-bed as well as people to deploy and implement the technology; Denso would provide the technology.

Metrics:
- The city of Marysville has upgraded 27 traffic signals with Dedicated Short-Range Communication Radios (DSRC) that can relay data and safety information to vehicles.
- DSRC devices provide real time data that is being incorporated by vehicle manufacturers.
- 8 DSRC devices are deployed in Marysville and the Public Services Department oversees the web-based 'maps' of traffic patterns created from the DSRC data.
- Over 250 companies including over 70 automotive companies have been involved in the project.
- The "fiber collaborative" of the project has installed 39 miles of fiber optic cable along the 33 Corridor with 42 more miles nearing completion.
- International corporations (Denso, Honda) and Higher-Ed institutions (OSU, Transportation Research Center) are using 33 Corridor as a testing bed for new technology.

PITTSBURGH

Methodology/Roadmap:

- Pittsburgh utilizes existing partnerships and research to reduce the logistical and financial cost of Smart Community programs.
- The implementation of Smart Community initiatives starts with a Mayor's Roundtable Series, held biannually, as well as feedback sessions for the Innovation Roadmap.
- These sessions and series are open to the public and members of the business community.
- The Department of Sustainability and Performance evaluates existing problems in Pittsburgh and raised during the series/sessions to determine scope and feasibility.
- During the categorization/prioritization process, the Department of Sustainability and Performance communicates with Carnegie Mellon University (Metro21Lab, Traffic21, etc.) to ensure that research at Carnegie Mellon matches needs of the city government.
- Once prioritized/categorized, a "Roadmap for Sustainability and Innovation" is published by the Department of Sustainability and performance.
- Communication between Carnegie Mellon's research labs and the City of Pittsburgh government is ongoing and constant.
- Metro21 works directly on city-identified problems, as they arise and are identified.
- In 2020, Pittsburgh will eliminate the Innovation Roadmap, replaced by a "Civic Innovation Specialist" who will identify potential partnerships, matching CMU research solutions with existing problems in Pittsburgh.

History/Origin:
- SmartPGH and Metro21 Lab both came out of disparity between technology/innovations available and services actually being provided.
- The Metro21 Lab grew out of the need for Pittsburgh to recover from the recession and population decline in the 1990s.
- Carnegie Mellon (home of Metro21 Lab) has a long history of innovation, with Metro21 Lab beginning in 2009 to deploy CMU research in Pittsburgh.
  - Metro21 Lab/Pittsburgh utilize CMU's existing partnership with GM established in 2000, a $3 million collaborative lab.
  - Technology and research from students and researchers already deployed by Pittsburgh.

Project: **Carnegie Mellon University Metro21 Lab**

Key Players:
- Karen Lightman, Executive Director of the Metro21 Lab at CMU is in direct communication with the Department of Innovation and Performance, Directed by Heidi Norman and Sylvia Harris.
- Metro21 Lab acts as an in-between and focuses the research at CMU on solutions for city-identified problems.
- CMU Professors/researchers are incentivized by gaining proof of concept and the experience gained by implementing their research. The city benefits by having problem-oriented solutions directly related to city issues.
- Communication is not restricted to the planning process and researchers are able to propose technologies and solutions as they come up.
- Department of Innovation and Performance oversees the determination of Smart Community projects, but actual department involvement is project-specific.

- Uber RiverFront Testing Facility — to test autonomous vehicles in connected vehicle platform

Sources of Funding:
- $300M invested by private industry, incentivized by proof of concept and as a test be for technology
- A primary objective of Pittsburgh Smart Community initiatives is to keep spending at a minimum.
- Projects can be funded through the city budget and the grant proposal process is run by the Mayor's Office in Pittsburgh.
- Pittsburgh awarded U.S. DOT Smart City Challenge Grant.
- Utilizing already available partnerships has been the main source of project implementation in Pittsburgh.
- Researchers at Carnegie Mellon have an incentive to utilize the city of Pittsburgh as a "test bed" for their technology and in exchange, Pittsburgh gets technology ready for transfer without the grant proposal process.
- $300,000 allocated in funding in 2018, focused on CMU research addressing the issue of landslides in Pittsburgh region.
- Reallocation of existing sources of funding — smart-trash cans, for example, were implemented by the Department of Public Works and deployed with money saved from increased efficiency and reduced travel time of garbage collection.
- PGH Lab is a major source of revenue creation, allowing the Pittsburgh government to support and incubate private start-ups, creating innovative technology and research solutions that can be tailored to match Pittsburgh-specific problems.

Metrics:
- Using Carnegie Mellon technology and research, Pittsburgh has increased traffic flow efficiency, reduced fire risk, optimized government services, and incubated startups.
- "Surtrac" Project: Travel time reduced 25%, wait time reduced 40% during rush hour, by using CMU algorithm for traffic planning (CMU Report on Surtrac, 2013).
- CMU data analysis of fire incident data, created predictive models of building's fire risk.
- CMU researchers created a route-planning algorithm to reduce the amount of U-turns a snow plow truck takes.
- Metro21 Lab and SmartPGH have both led to the creation and use of start-up technology in Pittsburgh.

UNIVERSITY OF MICHIGAN: MCITY TEST FACILITY

History/Origin:
- Officially opened July 20, 2015. First step toward MCity opening was December 18, 2008 when U-M bought the property the test facility now sits on.

Key Players:
- Ford Motor Company, The University of Michigan, City of Ann Arbor, Planet M, Michigan Department of Transportation, Michigan Economic Development Corporation, American Center for Mobility, U.S. Dept. of Transportation, U.S. Dept. of Energy, General Motors Company, Econolite, Denso, Aptiv, Honda Motor Company, Intel, LG, State Farm, Toyota, Verizon, and many more minor partners.

Purpose:
- The Mcity test facility was created in order to test new technologies. Making sure they were being tested in a safe, controlled environment. This is essential before deploying automated vehicles on public streets and highways. The full-scale outdoor laboratory simulates the broad range of complexities vehicles encounter in urban and suburban environments.

Sources of Funding:
- $7.5 million federal mobility grant (2019), Industry partners invested in the second phase of funding (2017), started with a public-private R&D initiative (2014).

Specific Results:
- Lower-cost self-driving navigation system developed by student (2015), driverless shuttle (2018), and Verizon 5G ultra-wideband network (2019).
- There has been $26.5M spent on research, development, and deployment of projects. 100+ graduate and undergraduate students have spent 4,400 hours involved in Mcity testing and engagement since January 2017. as well as 50 faculty have been involved in Mcity funded research.

UNIVERSITY OF MICHIGAN: URBAN COLLABORATORY

Methodology:
- Partners with communities to solve real-world challenges and improve infrastructure.
- The interdisciplinary faculty team members work directly with city stakeholders to identify their needs and develop solutions. These solutions are guided by smart city technology.

Key Players:
- University of Michigan faculty and students, as well as city leaders and residents.

Sources of Funding:

- Taubman College Faculty Seed Support (University of Michigan), Urban Collaboratory, City of Benton Harbor Operating funds, UM Exercise and Sports Science Initiative, $3 million grant from the National Science Foundation, U.S. Dept. of Energy, U.S. Dept. of Transportation, Great Lakes Water authority, Kellogg Foundation, Community Foundation of Greater Flint, Genesee Health Systems, Greater Flint Neighborhood Coalition, Flint Neighborhoods United, Wayne State University, Genesee County Health Dept., National Center of Health Housing, student and faculty volunteer time, Daijaing Environmental (Republic of China), and $400,000 UM Third Century Global Challenges Initiative.
- The main operational goal is to develop connections between existing smart cities and promote connections between these existing collaborations.

URBAN FUTURE LABS, NY

History/Origin:
- The Urban Future Lab was started in 2013 as a partnership between the New York City Economic Development Corporation and NYU Tandon School of Engineering.

Key Players:
- NYU, Columbia, New York City Economic Development Corporation,

Methodology:
- The initiative brings together different projects in the clean technology sector under one sequential framework. Focus heavily on commercialising the technology as an engine for job creation and generating tax revenue.

Programs:
- PowerBridgeNY
  - A proof-of-concept center operating using research labs from Columbia, NYU, PUNY
  - Each team goes through the program – they work with a researcher, post-doc student, sometimes an outside person. They go through a customer discovery process to understand who they need to tailor their prototype and business plan for. Mostly private people. They have an external panel they pitch their project to. In that process, they have a pitch coach.
  - Should their pitch succeed, they receive $150000 to begin work on their prototype. The funding is tranched. The teams must fulfill certain technical and business milestones to receive the next tranche of their funds. There is a review panel consisting of mentors and various experts who meet every quarter to review their progress.
  - The aspect of vital importance is ensuring that the business plan matches the commercial plan. They want the commercial prototype they eventually come up with to match what the customer wants to test for. They conduct workshops where they prepare the teams for the process of starting a company i.e. how to incorporate, looking for investors/applying for SBRI, how to get meetings with VC people and understanding what the due diligence process looks like for them.

- ○ Within UFL, the idea was originally to have Powerbridge be a feeder for UFL. That has not been the case in practice because the groups that emerge at the end are still too much in their infancy.

- ● ACRE
  - ○ ACRE is the startup incubator. It was started in 2009.

- ● Clean Start Diploma Program
  - ○ This is the workforce development program within the structure.
  - ○ Its goal is to maintain a pipeline of qualified talent going into the clean tech sector.

Purpose:
- ● To improve sustainability and energy efficiency of city infrastructure.
- ● To create jobs by supporting start-ups that develop clean technologies used in buildings.
- ● To develop educational programs to bring in a pipeline of qualified talent to keep growing the clean tech sector.

Sources of Funding:
- ● Academic Institutions' Funds,
- ● NYSERDA Grant of $10 million with $5 million going to Columbia and NYU each at the beginning,
- ● Corporate sponsorship from the National Grid, Downtown Brooklyn Partnership, Urban Green Council.
- ● Rents from start-ups.

Specific Results:
- ● $251 million in economic activity, 57 companies Incubated
- ● $450M+ Capital Raised, 530+ Jobs Created, 88% Company Survival Rate

PROVIDENCE

Methodology/Roadmap:
- ● Mayor Elorza has set a goal for Providence to use technology to collect data that will be used to inform future policy.
- ● The city surveys its citizens who are directly affected by the technologies the city chooses to implement. After surveying the citizens, the city approaches different funding methods or ways to cut costs.
- ● Providence is currently in the process of applying for a grant through the Verizon Foundation for its 5G connectivity project. Providence utilizes the Urban Innovation Partnership to establish communication between key players in the city like the hospitals, universities, and more.
- ● The city involves the higher education institutions by distributing data to them for research, which cuts costs and creates community ties.

History:

- Providence is a historic city located in Rhode Island. Within the city and the surrounding area there are well renowned universities and colleges. The city has a large hospital and medical footprint that drives much of the economy and development.

Purpose:
- Providence sought out smart communities technologies to improve the lives of its citizens and create a more sustainable community. Mayor Elorza has made it a priority to collect good data from the technologies in order to analyze and then improve the city.

Key Players:
- The City of Providence – Like all smart communities, the local government needs some degree of involvement in the development. Providence has played a large part in discovering what its citizens need.
    - Prioritizing 5G connectivity in order to allow lower income students to have access to WiFi for school work and job opportunities.
- The Universities – Brown University has played the largest role in the city so far.
    - Policy Lab – An organization at Brown that utilizes their resources in data analytics to solve problems in the city especially pertaining to inequality. It connects back to the 5G connectivity focus.
    - The city uses undergrad and grad students at various schools to conduct research using the data the city has collected. This cuts costs and increases productivity and community ties. Ties into the funding issue.
- Corporations and Businesses –
    - Conversations with Verizon and Cox (industry power houses) are occurring to focus on the 5G issue.
    - Providence advertises business connection with companies focusing on separate issues:
        - Using partnerships with Cisco to pilot parking technology and smart streetlights technologies.
        - Mobileye's Shield technology will be utilized to ensure the safety of pedestrians, bikes and other vehicles. Data collected from the Shield technology will be used to inform adjustments to and future expansion of transportation systems piloted.
        - Vulcan partnerships ensure the plan has desired sustainability and emissions reduction impacts.

Sources of funding:
- Providence has received a grant from the Economic Development Administration at the federal level.
- As mentioned, the use of students at higher education institutions provides cheaper labor.
- Local foundations such as the Rhode Island Foundation have made contributions.
- The city has applied for a grant at the Verizon Foundation for its 5G connectivity project.

Metrics:
- The city has created partnerships and has set plans for implementation of various technologies. They have not yet done the implementation, but they have the framework.

SAN DIEGO/CHULA VISTA

Methodology/Roadmap:
- The city of Chula Vista was one of the first cities in the US to deploy an intelligent traffic system on their street lights.
- To get to this point, the city partnered with GE to develop a plan and conduct the actual implementation.
- Moving forward, the city has worked with other key players in the local area to develop organizations that streamline communication between stakeholders. The non-profit Cleantech San Diego established a board that is made up of representatives from each organization that has a stake in the smart communities development. These organizations include higher education. Institutions, governments, and private industry.
- The city also has the Innovation Council, which consist of private industry and other partners. These partners reach out to the city who has a point person in various departments who works directly with the outside organizations

History:
- Like Colorado Springs, Chula Vista is growing at a fast rate and the city is researching and implementing technologies to make it a smarter community that is well equipped to support growth.

Purpose:
- "The Bayfront presents a unique, once-in-a-lifetime opportunity to incorporate a comprehensive smart city infrastructure to not only meet environmental goals but to improve public safety, attract business, and generally improve the experience of Bayfront residents, visitors and workers" (City of Chula Vista – Smart City Strategic Action Plan 5).

Key Players:
- Municipal government – As a representative of the people, it is important that the city government targets technologies that will benefit citizens the most.
- University of California San Diego – Data collected from technologies implemented around the city is outsourced to UCSD for research.
- Corporations and Businesses:
  - The city partnered with General Electric to retrofit 9000 street lights with LEDs and implement 29 intelligent traffic systems at different intersections.

Sources of funding:
- Ballot measures. Chula Vista residents approved a ballot measure in 2016, which is a 10-year half cent sales tax approved for infrastructure replacement.
  - Part of the tax measure funded a $1.4 million computer-aided dispatch system replacement.
- Government and private grants.
- Ballot measures allow for match funding from other federal grants through organizations like the national science foundation.

- Growing tax revenue from expanding economy.
- Some projects may fund themselves, such as digital kiosks with advertisement space.
- The city has also used general fund money for projects.
- Academic and research institutions have exceptional access to grant opportunities that the city can utilize for proposed research to address a public need.
- The city believes that startups often spin off from research that begins at universities and research institutes.
- Employment benefits in Chula Vista.

Metrics:
- The city has upgraded 9000 of their street lights with LEDs. They have also implemented 29 intelligent traffic systems at various intersections.
- These systems are collecting data on traffic movement to optimize traffic flow and increase safety.

PURDUE UNIVERSITY RESEARCH PARK

Methodology/Roadmap:
- The Purdue EPICS Smart City is divided into an application development team and a visualization development team.

History/origins:
- Purdue EPICS SmartCity began in Spring 2017 in order to develop a more convenient way of recognizing and reporting road damage or incidents to the city.

Purpose:
- To modernize urban cities "by using information and communication technologies to increase operational efficiency, share information with the public, and improve both the quality of government services and citizen welfare."

Key Players:
- Purdue University and the city of West LaFayette

ATLANTA

Research Methodology:
- Communities within the Atlanta Metropolitan Region submit an application to the GeorgiaSmart Program. In the application, they should describe what technology they want to begin implementing and how it factors into improving service delivery, job accessibility or quality of life.

History:
- The initiative started in 2015 as part of the Renew Atlanta Infrastructure Program, where Atlanta was conducting a plan to renew its infrastructure.

Purpose:
- To use data as a tool to address urban challenges such as traffic congestion and promote public safety and environmental sustainability.

Key Players:
- City of Atlanta and Georgia Tech – Memorandum of Understanding, under Metro 21 Framework

Sources of Funding:
- Renew Atlanta Infrastructure Bond Program
- A community that becomes part of the program should match between 20 to 100% of the grant they are given by the City of Atlanta to start their project.

Specific Results:
- North Avenue Smart Corridor
  - They leverage data to facilitate and promote safer traffic flow and prioritize fire engines and ambulances traveling along the corridor on emergency response calls.
  - Georgia Tech stores and analyzes data generated by these Smart City tools, offering professors and students an opportunity to conduct original research and analyze trends.
  - The City will then use the research and analysis in short and long-term transportation planning.

UNIVERSITY OF DENVER

Methodology/Roadmap:
- Denver University's focus is on the implementation of renewable resources being used in a Smart Community. Denver University is working together with the local community, as well as getting help from federal partnerships through grants in order to facilitate Smart Community initiatives.
- Upon receiving a grant from the National Science Foundation, Denver University and the Center for Sustainable Infrastructure Systems (CSIS) which will manage the project, partnered together. There are groups that are put together in order to optimize the logistics of each project that is under the smart city. Scientists from all over the world will be involved in order to lead to greater progress and wider exposure.
- These groups such as Project X-ITE are community driven student entrepreneurship opportunities that allow for students to come up with ideas of their own or help growth in an area that is already happening.

History/Origins:

- Denver, Colorado, is taking a progressive approach to innovation. This is mainly because of pioneering that has been brought on by the U.S. Department of Transportations Smart City Challenge.
- Denver Smart City is trying to optimize city operations, as well as addressing challenges such as crime, traffic congestion, and air pollution.

Project: **Electric Power Grid Modernization**

Purpose:
- To provide renewable energy through the modernization of power grids.

Key Players:
- City of Denver: Main source of projects that are given to the University of Denver. These projects are seen as needs from the city and implemented into schools and other partnerships that are available to help.
- Project X-ITE: is a test bed for entrepreneurship opportunities that students are able to self-start or help with initiatives that are already in place.
- IEEE: is able to provide a comprehensive grid management solution to replace the existing Outage Management System that is in place. This is able to make the process of monitoring the smart grids more accessible than before as well as providing real time studies and situational awareness.
- U.S. Department of Energy: has supplied two grants to Denver University in order to help.

Sources of Funding:
- The National Science Foundation: this grant is dispersed amongst all of the smart city research that is currently being done, as well as funding for teachers, groups, and other initiatives to be incorporated. U.S. Department of Energy has supplied grants in order to help facilitate the Smart Community growth with the projects that the city has deemed fit.

Metrics:
- Electricity from renewable sources has more than doubled since 2010 this is up to almost 25% which is from increased wind power by nearly 2,000 wind turbines.
- The project has wired 1,000 new residences to a solar-powered smart grid. These grids are able to monitor energy usage in real time to be monitored to see the effects of the modernized smart grid.

AUSTIN

Methodology/Roadmap:
- Austin's primary focus is on the initiative for clean air and limiting pollution, this is being done through the use of electrifying fleets.
- Governments in the Austin, Texas region are working together in order to form a central hub "Mobility Innovation Center (MIC)" in order to put all collaborative efforts into one place.

- Austin is also working with the University of Texas A&M and the University of Austin in order to train students in their respective smart city fields how to use and implement the information gained from the hub.
- Austin has a diagram of how the interconnected project elements will be implemented. The City of Austin will provide oversight, structure, and support to transform Austin into a Smart Community. The board will be composed of agency executives from the Core Team, which includes the City of Austin's City Manager. The City Manager acts as the chief executive and will serve as the fiduciary point of contact for the USDOT. The Consortium Director manages the Smart City project and reports to the city manager.
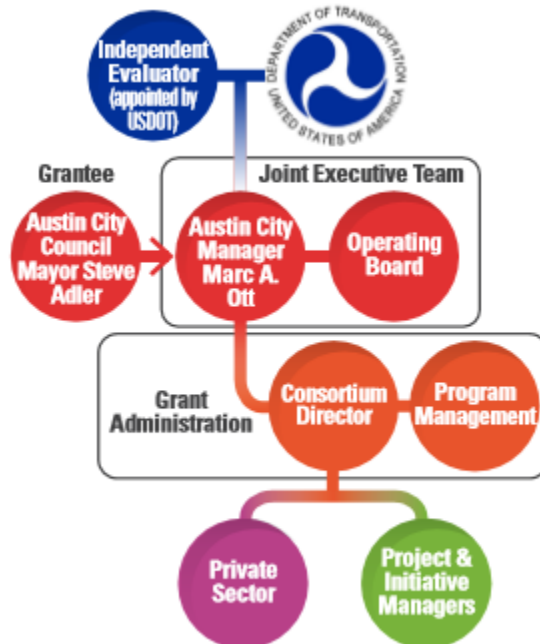
Figure 4 - Austin Organizational Structure

History/origins:
- Austin has been known as a "creative class" magnet, as well as being a progressive and innovative community.
- Due to younger generations there has been a demand for more choices for transportation which include more choices technologically.
- Austin was the first midsize test city for the Google Car, since this there have been many other car companies wanting to test in Austin, such as General Motors.

Project: **Mobility Transformation Initiative**

Purpose:
- The purpose of this project is to try and electrify any fleet that is projected to drive over 70,000 miles. This will help cut down on pollution and be able to create renewable energy.

Key Players:

- U.S. Department of Transportation has a lot of information to sway the opinions of the city when creating these smart city initiatives. Since the City of Austin is trying to electrify their cars and reduce pollution they want to have the information that the USDOT is able to provide to them.
- The City of Austin has a lot of key players implementing the MIC in order to have it staffed they will be appointing people from the city in order to overlook how the traffic is being monitored and what it is being used for.
- Ford: The have inquired about using Austin as a test bed in order to test out their smart driverless cars, as well as the electric cars that they have been working on in order to create a partnership between Ford and Austin.
- General Motors and Lyft: GM has invested $500 million in Lyft Austin is trying to facilitate a partnership in order to start deploying large numbers of GM electric transportation and network company (TNC) cars into the marketplace.

Sources of Funding:
- Austin prioritizes transportation investments based on the critical needs of residents.
- Austin failed in its bid to secure $40M in the USDOT's Smart Cities Challenge Grant (that funding instead went to Columbus). However, the prep work for that grant resulted in Austin winning the Smart Cities Council's Readiness Grant, which included support from a range of the largest and best global companies, that subsequently unleashed several rounds of (smaller) private investment.
- $10 million coming from Vulcan Philanthropy (an investment company).

Metrics:
- Austin's fleet charging stations are powered by 100% green certified renewable energy credits. By running on wind and sun power there are low, fixed charging costs of $4.17 per month which greatly improves business for electric vehicles.
- Austin uses Travel Access Hubs that would transform bus stops and parking lots into bustling transportation centers.

SmartCOS:

Recommendations for Developing Smart Partnerships

QUAD INNOVATION PARTNERSHIP

May, 2020

Student Research Leads:
Inna Oh (CC), Pietro Giacomin (CC), Aaron Bellot (PPCC), Tyler Alcon (UCCS), Griffin Anderson (USAFA), Shawna Westerlund (PPCC & UCCS)

QUAD INNOVATION PARTNERSHIP
CC | PPCC | UCCS | USAFA

Executive Summary

Partnerships between municipal governments, the private sector and higher education institutions around Smart Community technologies have catalyzed transformative impact in cities across the United States. This report details the application of key findings from a scan of nationwide partnership initiatives to the specific context of Colorado Springs and the SmartCOS initiative. The scan itself is detailed in a separate report.[1]

Mixed methodology was used to arrive at the final recommendations. The Metro21 Lab in Pittsburgh and Purdue Research Park in Indiana were priority examples used to inspire and refine findings, though other initiatives from the national scan were also incorporated.

Ultimately, a multi-step process was developed to evaluate, validate and pursue partnership initiatives that include municipal departments, private sector entities, higher education institutions and other types of partners. The process details:

1. *Initiative Sourcing*: Initiatives will likely come directly from the SmartCOS effort at first; however, the process also supports initiatives developed in other municipal departments and related to other efforts.
2. *Convening Partners*: Once an initiative has been approved, appropriate higher education, private sector, existing municipal partners and potentially other departments are engaged regarding specific roles, work and opportunities through an initiative process.
3. *Data Measurement and Data Dashboard*: Simultaneously, data should be captured and analyzed to establish baselines, prove opportunities for impact and justify necessary investment. Data should be published on a public-facing dashboard in order to cultivate community support and generate economic opportunity.
4. *Cybersecurity Testing and Partnership*: As initiatives begin to move towards implementation, associated technologies should be tested and evaluated to ensure that security and data management requirements are met or exceeded.
5. *Established Business Case:* This is an important threshold before deploying or implementing a project or initiative on a large scale. It is the proverbial "go/no go" check.
6. *Implementation and Ongoing Operations*: Once deployment is complete, ongoing data harvesting, mining and analysis can inform improvements and changes, resulting in future, better iterations of the work.

Additional considerations related to types of partnerships that might be developed through this framework, funding sources, data protection, and incentive alignment is detailed. A vision for a University Research Park is articulated to illustrate the potential for multi-faceted impact in the region. Finally, some potential funding sources are offered in the appendix. The City of Colorado Springs Office of Innovation is contemplated as the central convener and coordinator of this process.

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[1] Quad Innovation Partnership, *SmartCOS – Insights from Across the U.S.,* 2019.

This work was conducted by a team of interdisciplinary undergraduate students from the Quad Innovation Partnership, and commissioned by the City of Colorado Springs Office of Innovation.

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Study Introduction

Project Background and Phase One

The City of Colorado Springs (the City) has established several strategic goals for the near future: job creation, expanding infrastructure, and fostering collaborative relationships to better provide services to residents.- The City's Office of Innovation – in partnership with Colorado Springs Utilities – has piloted SmartCOS, a partnership that leverages advanced technologies to accomplish these objectives. The program features 11 priority concepts, listed at https://coloradosprings.gov/smartcos and discussed throughout this report. Simultaneously, the City's Economic Development Division (ED) is working to attract new businesses and help existing businesses expand in federal Qualified Opportunity Zones. This study from the Quad Innovation Partnership – a joint research initiative of Colorado College, Pikes Peak Community College, University of Colorado Colorado Springs, and the US Air Force Academy (insofar as authorized by Federal law[2]) – was commissioned to support the development of partnership initiatives related to SmartCOS and Economic Development objectives.

The research has three primary objectives:

1. Develop a body of well-researched information understanding successful partnerships between municipalities, startups and higher education institutions.
2. Apply findings from other communities and provide recommendations for how to structure and implement partnership initiatives suitable for Colorado Springs and that match City priorities.
3. Recommend methodology to measure impact and success of SmartCOS programs and partnerships

Research began during the fall 2019 academic semester with a scan of Smart Community efforts nationwide. A team of interdisciplinary students from all four Quad member schools conducted a literature review and engaged with key stakeholders of Smart Community efforts across the United States to understand what makes a Smart Community partnership effort successful. Findings were compiled into the *SmartCOS – Insight from Across the United States* report and delivered to the City in December 2019. This report is referenced as the December findings report throughout this document.

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[2] The Quad is not an entity of the Federal government and USAFA implies no Federal endorsement or underwriting of the activities.

Phase Two: Current Report and Model

This report summarizes research findings from part of the project's second phase. It directly addresses Research Objective 2: applying findings from other communities to the Colorado Springs context and recommendations on future partnership development.

The intent is for this report to serve as a road map for enabling partnership initiatives that leverage smart technology, are consistent with established SmartCOS objectives, and also contribute to improved delivery of City services, benefit resident quality of life, and support expanding economic opportunity in the community.

Student research leads employed mixed methodology to arrive at the final recommendations, including literature review, stakeholder engagement, design thinking, and direct interviews. Specific guidelines, standards, and structures were identified and included from regional and national bodies. Per City instruction, the Metro21 Lab in Pittsburgh and Purdue Research Park in Indiana were priority examples used heavily to inspire and refine findings. The other communities researched in Phase 1 were used in a similar capacity. Emphasizing the existing local market strengths has been a central element to research procedures as well.

A separate document and measurement model delivered alongside this report will directly address Research Objective 3. The document will detail methodology and findings related to measuring Smart Community project benefits, and the model offers rudimentary measurement capability.

Both components (current report and model) of Phase 2 were collaboratively developed by a team of six interdisciplinary students representing all four schools in the Quad partnership. Work was supported by a committee of faculty experts from a range of disciplines and overseen by professional management staff.

Key Findings: Partnership Development

Objectives

1	• Devise a protocol for implementing SmartCOS partnerships and pilot installations
2	• Extrapolate existing partnerships identified in Phase 1 that can yield desired results
3	• Show the result
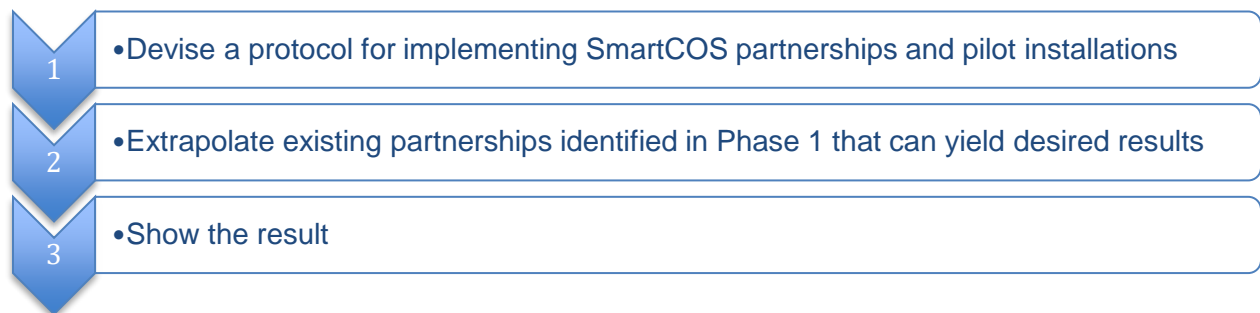
Background

The City's goals for this study included the prioritization of multi-sector partnership opportunities with emphasis on municipal, higher ed, and private sector partners. The December findings report detailed three characteristics of the most "successful" Smart Community partnership efforts and initiatives that included a similar mix of stakeholders:

1. **Willing, mutually-focused industry and higher ed partner(s)**
   Active involvement of partners with fundamental strategic alignment with project objectives ensures project remains a priority for all stakeholders

2. **Diverse funding sources**
   Layering multiple funding sources aligned with strategic objectives leads to more successful and sustainable initiatives

3. **Unique, focused projects**
   Projects with specific and achievable objectives that balancing ambitious strategy and specific metrics were most successful in studied communities.

Further, the December findings report detailed four specific initiatives as "most successful" out of over a dozen analyzed. Two were municipally-led and two were university led.

- Municipally-led initiatives: Metro21 (Pittsburgh) & Smart33 (Columbus)

- University led initiatives: MTEST/Urban Collaboratory (University of Michigan) & Urban Future Labs (NYU)

The Purdue Research Park in Indiana was also added as a "best practice" example for Phase 2, as other, related initiatives in Colorado Springs are using it as a model.

Based on prior analysis and City feedback, the Metro21 Lab in Pittsburgh was used in Phase 2 as the strongest example of a successful partnership for the Colorado Springs context. However, Phase 2 research was careful to incorporate key structural differences between Metro21 and any future effort in Colorado Springs. For example, Metro21 has a dedicated staff that serves as an intermediary between higher ed, private, and municipal partners. Carnegie Mellon University serves as the hiring entity for that staff. Per City feedback and in consideration of resource constraints and structural differences in municipal and higher ed agencies, the same dedicated and quasi-independent staff model is not feasible in Colorado Springs. Instead, the Office of Innovation may likely play that role instead. However, the various roles, responsibilities, processes and structures employed by Metro21 to strengthen collaboration are extremely valuable in elucidating next steps for Colorado Springs.

Finally, the December findings report also recommended that successful Smart Community initiatives be aligned with existing strategic strengths of a region or set of partners. Metro21's work is focused on advanced transportation technology, aligned with the fundamental economic assets of the Pittsburgh area. Cybersecurity and defense are fundamental strengths of the Colorado Springs economies. Importantly, the defense sector uses similar standards and technologies as civilian cybersecurity work. To that extent, the recommended model is built with a focus on cybersecurity and should therefore yield benefit to both sectors.

Recommended Structure

This structure integrates key findings from Phase 1, the strong relevance of Metro21 and the Purdue Research park to Colorado Springs as well as formal standards, guidelines and approaches from the National Institute of Standards and Technology (NIST)[3] and Smart Cities Council (SCC)[4]. Based on consultation with the City throughout the development process, it should also be consistent with the systems and processes the City already has in place. Of course, this recommendation should be considered preliminary and adjusted as needed in response to evolving circumstances in the community and within each partner entity.

The stakeholders/partners we have identified for the recommended partnership structure include the following:
- Residents
- Private sector businesses
- Nonprofits
- Higher Ed
- Cybersecurity partners (or Defense)

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[3] Guidelines and more information: https://pages.nist.gov/smartcitiesarchitecture/
[4] Guidelines, recommendations and more information: https://smartcitiescouncil.com/

- Municipal agencies and departments (including Colorado Springs Utilities, as appropriate per their involvement in SmartCOS)

This structure (Figure 1, below), currently called the *Cluster of Innovation*, emphasizes collaboration between and among the six stakeholder categories.

As new initiatives are proposed by the Office of Innovation or other City departments, they will be reviewed and analyzed to ensure alignment with SmartCOS goals (or other goals as deemed appropriate by the City). Collaboration between City departments for this review work should be clearly and separately structured. Then, the Office of Innovation will convene partners (private sector, higher education, etc.) and begin moving towards implementation.

Simultaneously, the SROI and other metric measurement activities will be conducted in order to establish baselines and demonstrate each initiative's potential for impact. This will also establish justification for necessary investments. Additionally, at this pre-implementation stage in the process, initiatives will go through extensive cybersecurity and data security testing to ensure safety and protect public trust.

This process – discussed in more detail below - will ensure that new ideas and proposals meet appropriate standards, are consistent with City goals and ultimately result in safe, secure and useful initiatives. Further, requiring vigorous cyber testing can further strengthen Colorado Springs' reputation and support further growth in the sector locally. This kind of testing will support the continued growth of cyber research and development (R&D) activities locally. In this way, this structure can achieve both the City's service delivery goals and its goal to bolster economic activity.

The recommended process is as follows:

1. *Office of Innovation Role*: The Office of Innovation, in this structure, plays the role of convener and facilitator of the review and execution process. In this way, the structure is similar to Metro21, however, with internal City staff playing the role that independent staff play in Pittsburgh. The Office of Innovation offers initiatives of its own, or receives proposals from other City departments aligned with the purpose and goals of this process. Then, the Office of Innovation convenes appropriate partners (higher education, private sector, or other, existing City partners), data measurement and cybersecurity components. Ultimately, the Office of Innovation coordinates implementation as well as ongoing operations and measurement work, unless there is a reason for some other entity to lead that work.

2. *Initiative Sourcing*: Partnership initiatives related to the 11 SmartCOS initiatives are the anticipated starting point. These initiatives will originate in the Office of Innovation. Other initiatives from the Office of Innovation can also use this structure. Additionally, other City departments can be consulted for priority projects.
   a. The "FILL" icon in the Internal City Framework of Figure 1 represents a generic city department that will propose or initiate an initiative. The process flow

depicted represents other City departments that should be involved in the review process in order to ensure alignment with City resources and priorities.

Each individual project may require a different mix of departments interacting in a different order. The figure below provides a sample of some the departments that might be involved. A firm internal process should be established through further engagement with each department.

Once review is completed, the initiative proposal will be transferred back to the Office of Innovation for next steps.

3. *Convening Partners:* This is where higher education, private sector, existing City partners, and potentially other City departments are engaged regarding specific roles, work and opportunities in initiative conversations. The December Findings Report found that this work in other communities has not been standardized. The widely-disparate parameters of each project require a different group of stakeholders be convened and an iterative set of conversations and steps utilized to secure appropriate involvement. Considering the proposed role for the Office of Innovation, this iterative work should be initiated and facilitated by Office of Innovation staff.

   This work will begin with convening and continue through implementation and ongoing operations.

4. *Data Measurement and Data Dashboard***:** Simultaneous with partner convening is the first opportunity for data measurement and publication (if appropriate) via a public-facing data dashboard. This measurement work will focus on establishing baselines as well as proving opportunities and mechanisms for impact through a specific project or initiative. This information could be used to justify and secure any necessary investment. This "forecast measurement" work should be convened and coordinated by Office of Innovation staff, consistent with their role.

   As a project moves into implementation, data measurement work will shift to capturing real time performance and evaluating long term impact. As discussed below, publishing this information on a secure, public-facing dashboard (potentially a partnership effort in and of itself) will not only provide transparency and cultivate community support for the work.

5. *Cybersecurity Testing and Partnership***:** This work also occurs as initiatives begin moving towards implementation, but before actual deployment of any project technology or components. Most importantly, this work involves ensuring all technology meets City security and data management requirements. This includes not just ensuring a technology is robustly protected from potential hackers or other threats, but that data will be appropriately stored, sanitized and available for public use. This work and information should again be convened and coordinated by Office of Innovation staff, consistent with their role.

This work is also where testing related to a "seal of approval" (discussed below) could be incorporated into the process to provide additional economic opportunity in the region.

6. *Establish Business Case:* This is an important threshold before deploying or implementing a project or initiative on a large scale. City Review, Partner Convening, Data Forecasting and Cybersecurity Testing work should yield high confidence that the project will achieve the anticipated outcomes, is consistent with City goals, and otherwise comprises a good investment.

7. *Implementation and Ongoing Operations*: This is when a project goes "live" at full scale (some limited deployment might be necessary for testing and evaluation). Once deployment is complete, ongoing data harvesting, mining and analysis can inform improvements and changes, resulting in future, better iterations of the work.

Figure 5 - Cluster of Innovation
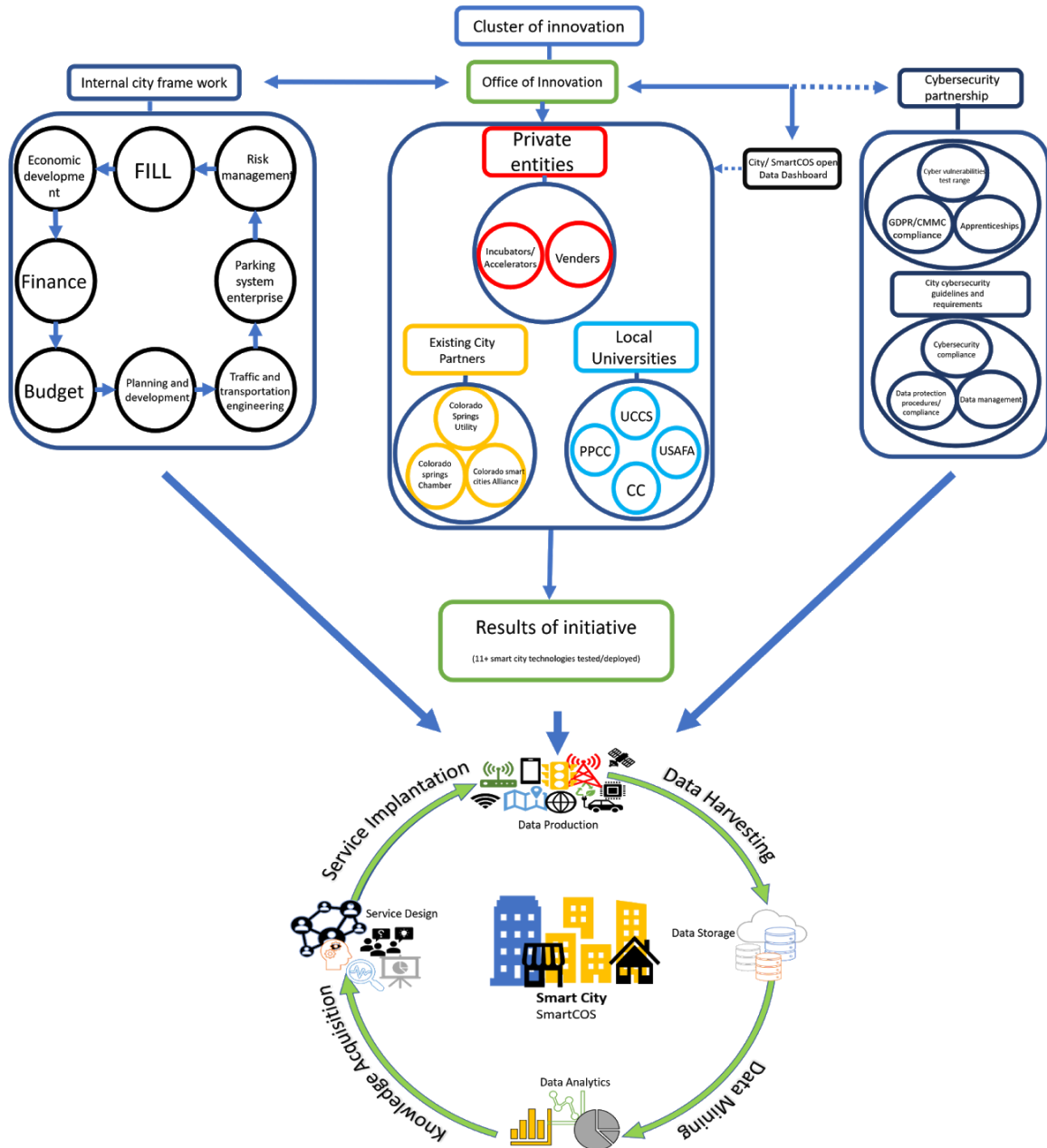
This structure was designed with the intention of long-term efficacy. As mentioned, the immediate priority is the successful implementation of the City's existing 11 SmartCOS objectives and associated technologies. The partnerships necessary for those 11 objectives will involve many diverse entities; this structure allows each initiative to be delegated to appropriate tactical sub-groups, coordinated by the Office of Innovation, for faster implementation.

Applying the Structure: Types of Partnerships

Consistent with NIST smart cities and community framework guidelines, building a Smart Community is a multi-step process, each requiring somewhat different types of partnerships. First, important infrastructure must be built to sustain, protect and enable the application of smart technology in areas where it was not used before. This includes data management and network infrastructure, as well as things like electrical service, control nodules, and a range of other things that enable smart technologies to work (discussed further below). Then, specific technologies can be deployed through other partnerships to achieve improvements in service delivery and operations. Finally, additional partnerships can be used to study and evaluate impacts and generally bolster capacity for innovation and further improvement.

It is useful to consider these steps as unique and specific categories of partnerships related to Smart Community development.[5]

Category 1

Cross-cutting and Foundational Issues: This category addresses issues impacting all aspects of smart cities and communities' development, such as data, platforms, key performance indicators, municipal IoT, cybersecurity and privacy.

Category 2

Sector-specific Issues: This category addresses smart city and community services, such as smart transportation. This would include the 11 initiatives.

Category 3

Implementation, Methods, and Approaches: This category provides publications addressing collaboration, innovation capacity building, education, procurement, economic sustainability and more.
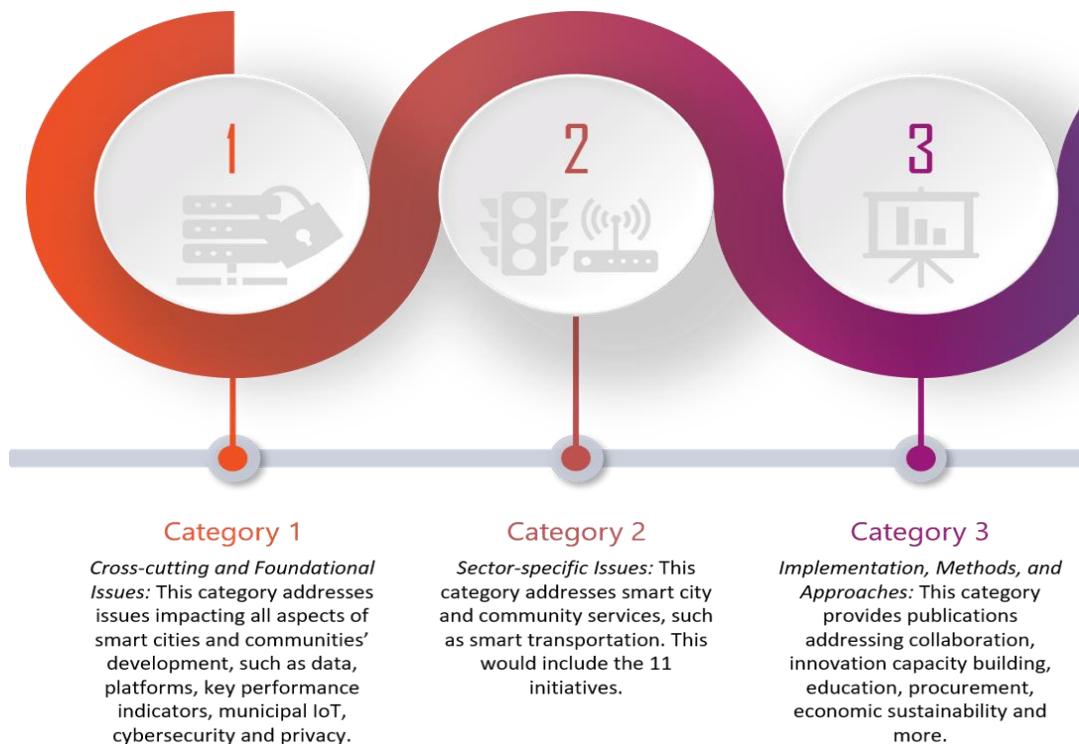
Figure 6 - Partnership Categories, from https://www.nist.gov/el/cyber-physical-systems/smart-americaglobal-cities/nist-smart-cities-and-communities-framework.

1. Category 1: Foundational and Tactical Objectives

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[5] NIST Categories: https://www.nist.gov/el/cyber-physical-systems/smart-americaglobal-cities/nist-smart-cities-and-communities-framework

Initiatives to manage and secure data collected by smart technologies.

Category 1 partnerships should be considered the most immediate need, as other categories of partnership require Category 1 initiatives to already be underway. Stakeholders and partners should be secured as soon as possible. Existing partnerships and relationships can be given preference in consideration of staffing and fiscal constraints.

2. Category 2: Sector-Specific and Strategic Objectives
   All partnership initiatives related to strategic goals and sector-specific objectives for performance improvement.

   Once Category 1 partnerships are in place, Category 2 partnerships can be pursued and finalized in order to achieve specific SmartCOS objectives. It is not necessary for all Category 1 partnerships to be in place before pursuing any Category 2. But every one of the 11 existing SmartCOS goals will require some Cateogry 1 partnerships to be finalized before Category 2 partnerships to achieve the goal are possible. There can certainly be overlap in Category 1 and Category 2 partnership development work.

3. Category 3: Methods, Approaches and Capacity Building
   This category is likely the broadest and includes all partnership initiatives related to further innovation and improvement in Smart capacity overall. Examples range from research partnerships that could result in academic publications or new technologies to operational partnerships that improve collaboration among multiple stakeholders, improve tactical efficiency, or build capacity in other ways (financial savings, etc.).

Potential Funding Sources

The December findings report identified the value of using a diverse and multi-faceted funding array to support the implementation of Smart Community initiatives. There are numerous potential sources of funding including Federal or State grants, municipal taxes, private grants and competitions, research grants, and corporate or industry partnerships. The December findings report includes information about funding sources for many of the communities studied

Prior to the COVID-19 Global Pandemic, the City included $172,000 in its annual budget for SmartCOS initiatives. About half of that annual allocation was already committed to various implementation contracts, leaving only a small amount of funding available for further work. Many Smart Community initiatives require multi-million dollar investments – the City budget is likely not a source of meaningful funding. That said, SmartCOS has proved itself capable of securing funding from other sources. For example, the revitalization of Southwest Downtown has already secured an estimated $42 million in funding from various sources to deploy smart technologies in the defined geographic area.

Specific next steps to secure funding for partnership initiatives will depend largely on the nature of the partnership. For example, partnerships (regardless of category) that offer private sector partners opportunities to test and develop new product lines could be funded by the partner. The December findings report drew a distinction between "partners" and "vendors", with "partners" representing private sector organizations with strategic alignment with the initiative. An example would be a theoretical company being able to launch a new product line as a result of their partnership with SmartCOS; the potential revenue of that product line would be strong justification for the company to support the initiative financially.

Identifying private partners who are strategically aligned with project objectives is an involved process with no guarantee of success. Grants are a more likely avenue for funding, though the grant landscape changes rapidly. The economic fallout of the COVID-19 pandemic will likely contribute to greater variations in grant availability.

The SPIN funding database is recommended as the best way for identifying federal funding opportunities. Sample searches through this study found several open funding opportunities related to cyber infrastructure and building smart, sustainable and resilient communities. Identified funding opportunities are included in Appendix A. The COVID-19 pandemic may have affected the parameters of these opportunities; a new search of the SPIN database should be conducted to identify post-pandemic grant opportunities.

The SPIN database provides a "funding outlook" with all information needed to understand and potentially pursue specific funding opportunities.

SPIN ID	Program Title
075548	Civil Infrastructure Systems (CIS)
Contact Name	~~Cynthia Chen~~
Contact Telephone	~~703-292-2000~~
Contact Email	~~xxxxx@nsf.gov~~
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=306193
Program URL	https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13352
Deadline Dates (ALL)	
Synopsis	The Civil Infrastructure Systems (CIS) program supports fundamental and inno
072409	Energy, Power, Control, and Networks (EPCN)
Contact Name	~~Radhakishan Baheti~~
Contact Telephone	~~703-292-2000~~
Contact Email	~~xxxxx@nsf.gov~~
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=306481
Program URL	https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505249

Figure 7 - Sample-Funding Outlook

Key Consideration: Data Protection

Network connectivity is essential to Smart Community initiatives. The concept of a "Smart Community" is made possible by improvements in connectivity that allow for data to be collected, analyzed, processed, and acted on in real time. Offsite computing is key and the networks that connect individual city technologies – like street lights, trash cans, and a range of sensors – to the various systems that receive, analyze and interpret data are essential. Every point in these networks should be considered vulnerable to attack and therefore protected. Today, cybersecurity procedures, data protection guidelines, and other security infrastructure are still emerging within the City. Finalizing this infrastructure is a necessary prerequisite to the safe, secure and effective implementation of any smart technology.

The City currently has internally developed security protocols, key industry partnerships and relationships with many institutions of higher learning and research locally. These existing resources provide a foundation to develop additional relationships and finalize security infrastructure. The City is already engaged in relevant conversations with several potential partners. These partnerships and the associated work to develop security infrastructure is important and should remain a priority in order to ensure successful implementation of SmartCOS initiatives.

<div align="center">Alignment with NIST Guidelines[6]</div>

Identify a clear pathway toward an adaptable, sustainable, and secure technology marketplace and smart city

Promote innovation in the infrastructure for dynamic adaptation to evolving threats

Promote innovation at the edge of the network to prevent, detect, and mitigate automated, distributed attacks

Promote and support coalitions between the security, infrastructure, and operational technology communities domestically and around the world

Increase awareness and education across the ecosystem

Figure 8 - Alignment with NIST Guidelines

As the City progresses through this work, data governance and protection considerations will become increasingly important. Data governance refers to the inclusive set of procedures and policies regarding the people, processes, and technologies needed to manage an organization's data assets in order to guarantee generally understandable, correct, complete, trustworthy, secure and discoverable data. This work is often the domain of Platform as a Service (PaaS) or Software as a Service (SaaS) vendors. There is no single "answer" to data governance on a city level. Each city should develop its own policies and procedures suitable to the work in its domain and associated data. However, moving from a "standard" city to a "smart" city adds many new dimensions to data governance overall; working through these new dimensions proactively is important for successful implementation. Cybersecurity Maturity Model Certification (CMMC) and General Data Protection Regulation (GDPR) standards may be helpful in that work.

Partnerships related to Data Protection should be considered Category 1 partnerships. They pertain to foundational infrastructure that other smart technology initiatives will depend on.

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[6] Guidelines adapted from: https://pages.nist.gov/smartcitiesarchitecture/

Cybersecurity Partnerships

The comparative strength of the local cybersecurity sector and associated infrastructure is a key advantage for the City in not only implementing SmartCOS objectives, but also in maximizing their direct impact and translating them into economic opportunity.

In Pittsburgh, Metro21 works with the Western Pennsylvania Regional Data Center to protect and publish city data. The data is then made available to the public via a dashboard. Several startup companies have used data collected by the city in the development of their product or service without compromising the security of the data. Pittsburgh also offers a live-data view as a complement to historical data, branded *Bird's Eye View.* This helps residents feel connected to the virtual "pulse" of the city. Pursuing a similar system in Colorado Springs will yield similar benefits: residents can access a new form of connection to their community and universities, private partners, startups and other entities can access important information that will benefit research, innovation and opportunity.

Figure 9 - Data Publication and Review
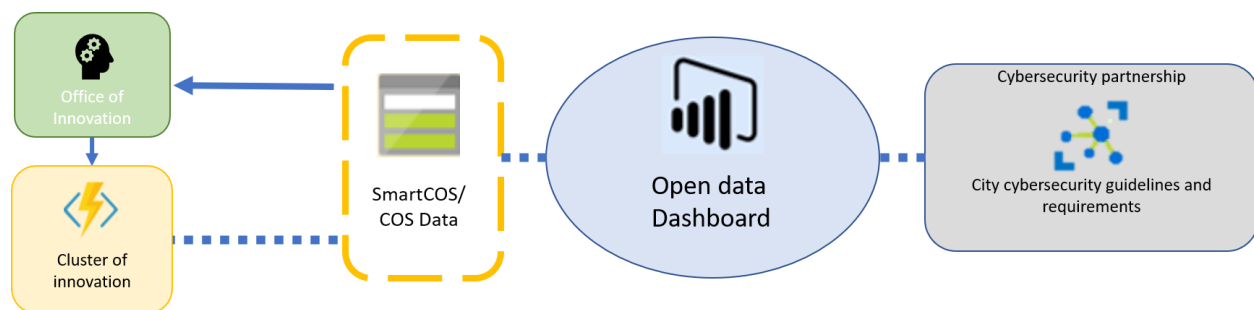
By adopting this structure, published data would be scrubbed of any identifying information or any other components that could lead to harm. Data sets or technology systems interacting with the dashboard should be tested for vulnerabilities. Any non-sharable data would remain the City's responsibility to collect, protect and use as appropriate.

Any partner able to operate the dashboard and/or do the cybersecurity and data protection components would need to be compliant with GDPR standards at a minimum, and should have secured or be seeking additional compliance certification through a testing lab or vulnerability assessment.

Working with existing area partners and organizations, the City can add additional significance and opportunity to cyber testing labs and vulnerability assessment organizations. Compliance certification and the development of an industry-standard "seal of approval" could also result. If deemed feasible and not harmful to implementation, developing a "seal of approval" with a local partner could add significant value to Colorado Springs as a location for cybersecurity businesses and research.

Requiring such a seal would provide an additional layer of security for the City and residents as initiatives are launched and technologies are deployed. A meaningful "seal" does not currently exist related to cyber and data security within Smart City technologies; it is a needed development within the sector globally in order to establish and validate adherence to best practices and, as mentioned, could yield economic benefits locally. The Colorado Springs-based National Cybersecurity Center is already exploring the development of testing and "seal of approval"-type certification. That is to say, opportunities already exist locally for the City to play a supporting role and not be required to lead.

General work to ensure the security of Smart Community data in Colorado Springs should be considered Category 1; it is an essential foundation for the success of SmartCOS. Work to develop an industry-defining "seal of approval" and associated research, testing, and development of such infrastructure locally could be considered either Category 1 or Category 3.

Communication Considerations

Communities around the country sometimes face pushback from concerned citizens related to initiatives that collect and use resident data. The full list of potential concerns is lengthy and variable, though privacy is generally a central theme. With large scale data breaches constituting a somewhat regular presence in national headlines, data security is also an important consideration.

Community-facing communication regarding data collection, use and security related to any SmartCOS initiative should be thoughtful, intentional and designed to steward community buy-in to the initiative. Some areas of focus for communication can include:

- **Data management protocols** within the City and within any partner entity. The processes and mechanisms related to how data is secured, sanitized and shared.
- **Industry standards and best practices**, and the initiative's performance in relation to them. For example, "bank-level encryption" or "military grade encryption" are common ways to compare security to a widely regarded "gold standard".
- **Alignment with stated concerns** or resident principles and values. Articulating shared values and demonstrating them with specific actions is an effective approach to helping people feel heard, valued and understood.
- **Answers to "why" questions**. Transparency towards residents will steward feelings of ownership and value, as well as understanding for why data will be used and agreement that security is adequate.

There are two main schools of thought related to communication timing: preemptive and reactive communication. Preemptive communication is the process of beginning dialogue before implantation to secure community support. This reduces the potential for backlash once the initiative is underway. primary benefit is the minimization of unexpected community pushback; however, no amount of communication can eliminate that risk entirely. This method can ignite significant opposition that prevents an initiative from ever being implemented, or delays project timelines significantly.

The other school of thought prioritizes responsive communication when a situation arises. This is a faster approach and eliminates the time required for upfront engagement. However, the risk of pushback once a project gets underway remains high and is amplified by the potential for community "surprise". Metro21 and the City of Pittsburgh employ this kind of responsive communication for many of their research and pilot efforts in order to maintain agility and in consideration of the comparatively minor implications of each of their smart initiatives.

Key Consideration: Stakeholder/Partner Priority and Incentive Alignment

Each individual stakeholder and stakeholder class will hold a range of goals and priorities motivating their respective involvement in a SmartCOS partnership. Consistent with the findings of Phase 1, ensuring these goals are aligned on fundamental and strategic levels is an important consideration as partnerships are developed and implemented. Some key priorities of each stakeholder group have been identified in order to highlight overlap and inform relationship development.

Smart City Stakeholder Priorities

Colorado Springs Residents	Business & Cybersecurity	Nonprofits	Higher Education Institutions	Municipal Agencies
• Quality of life • Economic opportunity • Ease of service • Financial Operational efficiency Perceived role of government • Trust in government • Privacy, safety and security • Community pride	• Revenue opportunities (new contracts or products) • Product R&D Relationship development • Future workforce development • Access to relevant knowledge and data	• Best practice and mission-aligned impact • Opportunities for further impact and to demonstrate excellence • Access to relevant knowledge and data • Funding opportunities • Community stewardship	• Student success (including both educational rigor and student-to-workforce pipelines) • Applied learning, research • Long- and short-term research initiatives • Publication opportunities • Funding opportunities • Community engagement and stewardship	• Improve delivery of citizen services (per scope) • Grow economic opportunity (per scope) • Department specific applications

Figure 10 - Stakeholder Priorities

Vision: University Research Park

There is already some conversation in the Colorado Springs community regarding opportunities to build and develop a University Research Park, these efforts draw inspiration from the Purdue Research Park in Indiana. Components of this conversation include the *Proposed University Research Park* white paper written by El Paso County Commissioner Stan VanderWerf. The white paper details findings from an exploratory visit to Purdue by a contingent of Colorado Springs-area leaders including representatives from the City, County, Chamber & Economic Development Commission and UCCS. The development of the National Cybersecurity Center (NCC) in a UCCS-owned building on North Nevada and subsequent conversations about how to

leverage long-needed redevelopment of the area into a research, innovation and technology hub are also contributing to community perceptions of opportunity. The addition of a research park would likely be a worthwhile component to smart city infrastructure.

Securing smart technology requires a strong research and development ecosystem. The shared overlap and work of the NCC, UCCS research initiatives and a range of private sector cybersecurity companies and the Exponential Impact startup accelerator (co-located with the NCC) is already contributing to a strengthening research, development and innovation ecosystem in Colorado Springs.

Pikes Peak Community College offers cyber secutriy courses for a 2-year degree or certificate, which seamlessly tranfer to other univierisities, like UCCS, Regis, and CSU Pueblo, and contribute to 4-year degrees. Additionally, Pikes Peak Community College offers a Secure Coding program, Neworking, AGS degree, and apprenticeships.

Colorado College has a well regarded computer science department, a coding club and senior thesis blocks. The College's focus on community-engaged learning and innovation is a strong starting point for collaboration in a research park.

The US Air Force Academy has world class research facilities and offers computer science, cybersecurity, and electrical and computer engineering programs. The Cyber Range allows for real-life cyber-attack simulations. All USAFA-led research falls under a congressional mandate to be made available to the private sector.

UCCS has strong cybersecurity education and research programs. It houses six engineering affinity societies and offers apprenticeships funded through grants, in addition to the upcoming BA of Cybersecurity. Cybersecurity is a major strategic focus; together with their Bachelor of Innovation and other research/commercialization programs means a strong foundation

Figure 11 - Existing Higher Education Opportunities

Further, as shown in Figure 7, all major Colorado Springs-area colleges and universities have strong programs and capstone opportunities for STEM fields, with particular emphasis in computer technology and cybersecurity. The strength of these higher ed programs and their existing collaboration through the Quad Innovation Partnership suggests opportunities for comprehensive inclusion of higher education institutions in a research park generating significant benefits to the entire Colorado Springs community.

The City's role in a University Research Park matching this vision would include many departments and offices; it would not be only a SmartCOS initiative. However, there is no research park or dedicated initiative nationwide focused on securing Smart Community technology. Requiring the hypothetical "seal of approval" discussed above could be a way in which SmartCOS contributes to the eventual development of a University Research Park in Colorado Springs. Making some City infrastructure (like a small set of street lights, traffic signals, etc.) available for pilot testing could be another way. In Pittsburgh, the Metro21 office has worked with the municipal government to streamline policies and procedures and make it permissible to test autonomous vehicle technologies and other advanced technologies on City streets. Engaging with research institutions similarly – and through the recommended partnership structure – represents another possible avenue of support.

It is worth repeating that this vision is far from reality. However, it is strongly consistent with the City's goals and represents a compelling concept for how to both advance the work and impact of SmartCOS while simultaneously contributing to enhanced economic opportunity for the region.

Appendices

Appendix A: Funding Opportunities

SPIN ID	Program Title	Sponsor Name	Sponsor #	Deadline	Funding Amount
075548	Civil Infrastructure Systems (CIS)	Directorate for Engineering/NSF	PD-19-1631	Continuous Submission	Not Specified
Contact Name	Cynthia Chen				
Contact Telephone	703-292-2563				
Contact Email	cchen@nsf.gov				
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=306193				
Program URL	https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13352				
Deadline Dates (ALL)					
Synopsis	The Civil Infrastructure Systems (CIS) program supports fundamental and innovative research in the design, operation and management of civil infrastructure that contributes to creating smart, sustainable and resilient communities at local, national and international scales. This program focuses on civil infrastructure as a system in which interactions between spatially- and functionally- distributed components and intersystem connections exist. All critical civil infrastructure systems are of interest, including transportation, power, water, pipelines and others.				
072409	Energy, Power, Control, and Networks (EPCN)	Directorate for Engineering/NSF	PD-18-7607	Continuous Submission	Not Specified
Contact Name	Radhakishan Baheti				
Contact Telephone	703-292-8339				
Contact Email	rbaheti@nsf.gov				
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=306481				
Program URL	https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505249				
Deadline Dates (ALL)					
Synopsis	The Energy, Power, Control, and Networks (EPCN) Program supports innovative research in modeling, optimization, learning, adaptation, and control of networked multi-agent systems, higher-level decision making, and dynamic resource allocation, as well as risk management in the presence of uncertainty, sub-system failures, and stochastic disturbances. EPCN also invests in novel machine learning algorithms and analysis, adaptive dynamic programming, brain-like networked architectures performing real-time learning, and neuromorphic engineering. EPCN's goal is to encourage research on emerging technologies and applications including energy, transportation, robotics, and biomedical devices & systems. EPCN also emphasizes electric power systems, including generation, transmission, storage, and integration of renewable energy sources into the grid; power electronics and drives; battery management systems; hybrid and electric vehicles; and understanding of the interplay of power systems with associated regulatory & economic structures and with consumer behavior.				
086910	Cyberinfrastructure Centers of Excellence (CI CoE)	Directorate for Computer and Information Sciences and Engineering/NSF	PD-20-139Y	Continuous Submission	Not Specified
Contact Name	William L. Miller				
Contact Telephone	703-292-7886				
Contact Email	wlmiller@nsf.gov				
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=322313				

Program URL	https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505744				
Deadline Dates (ALL)					
Synopsis	The Nation's advanced research cyberinfrastructure (CI) ecosystem catalyzes discovery and innovation across all areas of science and engineering (S&E) research and education. The increasingly complex and rapidly evolving S&E landscape requires an agile, integrated, robust, trustworthy, and sustainable CI ecosystem that will drive new thinking and transformative discoveries in all areas of research and education. The NSF Cyberinfrastructure Centers of Excellence (CI CoE) Program aims to realize the above vision by supporting hubs of expertise and innovation targeting specific areas, aspects, or stakeholder communities of the research CI ecosystem. Supported CI CoEs provide expertise and services related to CI technologies and solutions; gather, develop, and communicate community best practices; and serve as readily-available resources for both the research community and the CI community. A key objective of this program is to support CI CoEs that drive advancements in and positively impact the CI ecosystem through structured but strongly community-engaging and community-serving approaches. Overall, CI CoEs are a means of concentrating resources on a specific area of identified need in support of the broader goal of advancing capabilities and performance of the national CI ecosystem.				

089540	Cyberinfrastructure for Emerging Science and Engineering Research (CESER)	Directorate for Computer and Information Sciences and Engineering/NSF	PD-20-7684	Continuous Submission	Not Specified
Contact Name	William L. Miller (CISE/ACI)				
Contact Telephone	703-292-7886				
Contact Email	wlmiller@nsf.gov				
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=324725				
Program URL	https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505385				
Deadline Dates (ALL)					
Synopsis	The Cyberinfrastructure for Emerging Science and Engineering Research (CESER) program aims to catalyze new science and engineering discovery pathways through early-stage collaborative activities between disciplinary scientists and engineers as well as developers/implementers of innovative cyberinfrastructure (CI) capabilities, services, and approaches. Beginning in FY 2017, the CESER program replaced the Strategic Technologies for Cyberinfrastructure (STCI) program. CESER has retained STCI's focus on supporting innovation across the CI ecosystem with increased emphasis on addressing and enabling emerging areas of potentially transformative research, including NSF priority areas, national strategic directions, and international collaborative research.				

083753	Computer and Information Science and Engineering (CISE): Core Programs	Directorate for Computer and Information Sciences and Engineering/NSF	19-589	14-Sep-2020	Not Specified
Contact Name	Alan Sussman				
Contact Telephone	703-292-7563				
Contact Email	oac-core@nsf.gov				
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=317913				
Program URL	https://www.nsf.gov/pubs/2019/nsf19589/nsf19589.htm				
Deadline Dates (ALL)	14-Sep-2020 , 23-Sep-2020 , 12-Nov-2020				
Synopsis	The NSF CISE Directorate supports research and education projects that develop new knowledge in all aspects of computing, communications, and information science and engineering, as well as advanced cyberinfrastructure.				

085724	Secure and Trustworthy Cyberspace (SaTC)	National Science Foundation	19-603	Continuous Submission	1,200,000 USD
Contact Name	Nina Amla				
Contact Telephone	703-292-7991				
Contact Email	namla@nsf.gov				
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=320432				
Program URL	https://www.nsf.gov/pubs/2019/nsf19603/nsf19603.htm				
Deadline Dates (ALL)					

Synopsis	The goals of the SaTC program are aligned with the National Science and Technology Council's (NSTC) Federal Cybersecurity Research and Development Strategic Plan (RDSP) and National Privacy Research Strategy (NPRS) to protect and preserve the growing social and economic benefits of cyber systems while ensuring security and privacy. The RDSP identified six areas critical to successful cybersecurity research and development: (1) scientific foundations; (2) risk management; (3) human aspects; (4) transitioning successful research into practice; (5) workforce development; and (6) enhancing the research infrastructure. The NPRS, which complements the RDSP, identifies a framework for privacy research, anchored in characterizing privacy expectations, understanding privacy violations, engineering privacy-protecting systems, and recovering from privacy violations. In alignment with the objectives in both strategic plans, the SaTC program takes an interdisciplinary, comprehensive and holistic approach to cybersecurity research, development, and education, and encourages the transition of promising research ideas into practice. The SaTC program welcomes proposals that address cybersecurity and privacy, and draw on expertise in one or more of these areas: computing, communication and information sciences; engineering; education; mathematics; statistics; and social, behavioral, and economic sciences. Proposals that advance the field of cybersecurity and privacy within a single discipline or interdisciplinary efforts that span multiple disciplines are each welcome.

061446	Dear Colleague Letter: Encouraging Submission of Industry/University Cooperative Research Centers (IUCRC) Proposals in Areas Related to the Internet of Things	Directorate for Computer and Information Sciences and Engineering/NSF	NSF 17-072	Continuous Submission	Not Specified

Contact Name	Dmitri Perkins
Contact Telephone	703-292-7096
Contact Email	dperkins@nsf.gov
Sponsor Website	
Program URL	https://www.nsf.gov/pubs/2017/nsf17072/nsf17072.jsp?WT.mc_id=USNSF_25&WT.mc_ev=click
Deadline Dates (ALL)	
Synopsis	This Dear Colleague Letter (DCL) encourages collaborations between industry and academe in research related to IoT specifically and, more broadly, cyber-physical systems. The aim is to establish multi-university IUCRCs that, in collaboration with their industry partners, are capable of collectively addressing large-scale and cross-disciplinary challenges in the broad context of IoT. NSF therefore welcomes and encourages proposals in response to the IUCRC program solicitation, NSF 17-516, in the areas outlined in this DCL.

092037	Civic Innovation Challenge	National Science Foundation	20-562	01-Jul-2020	1,000,000 USD

Contact Name	David Corman
Contact Telephone	703-292-8754
Contact Email	dcorman@nsf.gov
Sponsor Website	https://www.grants.gov/web/grants/view-opportunity.html?oppId=326002
Program URL	https://www.nsf.gov/pubs/2020/nsf20562/nsf20562.htm
Deadline Dates (ALL)	01-Jul-2020 , 31-Mar-2021
Synopsis	The Civic Innovation Challenge (CIVIC) is a research and action competition in the Smart and Connected Communities (S&CC) domain designed to build a more cohesive research-to-innovation pipeline and foster a collaborative spirit. Building on the NSF S&CC program and the extensive S&CC ecosystem, CIVIC aims to accelerate the impact of S&CC research, and deepen cooperation and information sharing across sectors and regions. CIVIC will lay a foundation for a broader and more fluid exchange of research interests and civic priorities that will create new instances of collaboration and introduce new areas of technical and social scientific discovery. CIVIC will fund projects that can produce significant community impact within 12 months (following a four-month planning phase) — in contrast to many community-university partnerships that take years to provide tangible benefits to communities — and have the potential for lasting impact beyond the period of the CIVIC award.

The Bloomberg Foundation is one of the more prominent private funders related to civic innovation.

Appendix B: Western Pennsylvania Regional Data Center

The Western Pennsylvania Regional Data Center supports key community initiatives by making public information easier to find and use. The Data Center provides a technological and legal infrastructure for data sharing to support a growing ecosystem of data providers and data users. The Data Center maintains Allegheny County and the City of Pittsburgh's open data portal and provides a number of services to data publishers and users. The Data Center also hosts datasets from these and other public sector agencies, academic institutions, and non-profit organizations. The Data Center is managed by the University of Pittsburgh's Center for Social and Urban Research, and is a partnership of the University, Allegheny County and the City of Pittsburgh.

More information: http://www.wprdc.org/

Appendix C: Organizations Engaged in this Research

This is a partial list of all organizations and resources consulted in formulating this report. These organizations are included in the research and may hold potential for future partnership.

Air Force Academy Cyber City and Cyber Warfare test range — This test range could potentially be a tool for the city to understand and test the potential vulnerabilities of smart city technology.

CO-LABS — Connects scientists, universities and business. They ensure technologists, economic development experts, scientific thought leaders and elected officials can leverage the resources, discoveries and cutting-edge technologies available in Colorado's federal research labs.

Colorado Department of Transportation (CDOT) — Implements a variety of state and federal programs to complete projects that enhance the state's transportation network.

Cybernetica — Specializes in the discipline of cybernetics; how to effectively and efficiently govern a certain system or infrastructure, with the use of technology, and ICT (information and communications technology).

Google Cloud/AWS/Azure — Offers a cloud computing service that runs on the same infrastructure as Google/Amazon/Microsoft and provides a place for individuals and enterprises to build and run software.

EasyMile Denver — Delivers autonomous mobility solutions and recently just launched the first on-road deployment of an autonomous vehicle shuttle in Denver and the state of Colorado (EasyMile is owned and operated by the Regional Transportation District (RTD))

Innovation Corridor — Connects private entities with world-class national labs; partnered with Colorado Smart City Alliance

National Cybersecurity Center — Ongoing development of their Cyber Testing and Vulnerabilities lab holds strong potential

OCTO VMware — A virtualization and cloud computing software provider and a subsidiary of Dell Technologies. VMware bases its virtualization technologies on its bare-metal hypervisor architecture.

Qlik — Is a data aggregation and visualization platform that can be considered SaaS or PaaS platform. Qlik specializes in creating interactive dashboards that its users are able to tailor to their specific needs. This includes open dashboard functions and well as additional SROI capabilities.

Smart Connections Consulting — Ensures that the city chooses the most flexible and scalable technology available in the city that aligns with city goals and incentives.

Spectrum Mobile — provides 5G wireless technology in the United States and throughout Colorado.

UCCS Cybersecurity Initiatives — Range of potential roles, opportunities and existing cyber partners including Bluestaq, Kratos, BOECORE and Dilote, all of whom have provided community support for cyber initiatives.

View, Inc. — Specializes in smart city infrastructure and design.

Strategies for Measuring Impact

Recommendations for Capturing Social Return on Investment

The City's Office of Innovation and Sustainability (OIS) – in partnership with Colorado Springs Utilities – has piloted SmartCOS, a partnership that leverages advanced technologies to accomplish these objectives. The program features 11 priority concepts, listed at https://coloradosprings.gov/smartcos and discussed throughout this report. Simultaneously, the City's Economic Development Division (ED) is working to attract new businesses and help existing businesses expand in federal Qualified Opportunity Zones. Student research from the Quad Innovation Partnership – a joint research initiative of Colorado College, Pikes Peak Community College, University of Colorado Colorado Springs, and the US Air Force Academy (insofar as authorized by Federal law[7]) – was commissioned to support the development of partnership initiatives related to SmartCOS and Economic Development objectives.

Measuring impact and performance is essential to good municipal governance. Capturing the Social Return on Investment (SROI) of SmartCOS initiatives and beyond is essential in order to justify investment, evaluate performance, and show benefits delivered to citizens.

This document provides an overview of SROI measurement methodologies and explains a Microsoft Excel tool developed by a team of interdisciplinary students and delivered alongside the report. It is the third and final component of the complete set of work developed by Quad students through this partnership with the City.

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[7] The Quad is not an entity of the Federal government and USAFA implies no Federal endorsement or underwriting of the activities.

Defining SROI

SROI is a measurement method capturing types of value created from an investment beyond financial profits and not typically captured in standard financial return calculations, like social or environmental components. In practical terms, SROI enables organizations to measure and communicate how they create positive change. Calculating SROI typically involves assigning monetary values to the social impact created in order to help organizations and individuals easily understand comparative performance. For example, a hypothetical organization claiming "for every dollar invested, we provided 2 meals to people in need" is more difficult to evaluate in relationship to other potential social investment opportunities than a hypothetical claim of "for every dollar invested, we generated $7 in social value." The latter enables a proverbial "apples to apples" comparison while the former does not.

Measuring SROI can be accomplished through a variety of methodologies. The UK Cabinet office, in partnership with Social Value International and a consortium of best practice research organizations identified seven core values as foundational to SROI measurement.[8] The values are[9]:

1. **Involve stakeholders**
   Ensure those with close proximity and connection to the work inform decisions about what gets measured.

2. **Understand what changes**
   Identifying a complete set of dependent and independent variables – including those representing positive and negative outcomes and also intended and unintended affects –

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[8] Social Value UK, *A Guide to Social Return on Investment 2012*, http://www.socialvalueuk.org/resource/a-guide-to-social-return-on-investment-2012/

[9] Value titles quoted and explanations summarized from:
Social Value International, *Principles of Social Value*, https://socialvalueint.org/social-value/principles-of-social-value/

is important for capturing total performance. Additionally, identifying mechanisms of impact supports comprehensive and accurate measurement and analysis.

3. **Value the things that matter**
    Measurement and assessment can be resource intensive. Make decisions on the basis of the relative impact between outcomes and metrics. Value stakeholders in these decisions.

4. **Only include what is material**
    The goal of measurement is for stakeholders to be able to draw reasonable conclusions about impact. Prioritize only what evidence is necessary to provide an accurate picture. If there is information that might sway a decision about the activity by stakeholders, it should be included.

5. **Do not over-claim**
    Only claim the impact that can be decisively proven from specific activities; do not extrapolate beyond what is certain.

6. **Be transparent**
    SROI measurement is not always a perfect science. Discuss methodology and share the basis on which measurement and analysis can be considered accurate and honest, or any weaknesses; include stakeholders in reporting and decision making.

7. **Verify the result**
    Engaging independent auditors for verification is best to establish credibility and confirm impact.

Determining SROI: Methodology Overview

At the most basic level, SROI can be calculated as:

$$SROI\ Coefficient = \frac{Value\ of\ Impact}{Value\ of\ Inputs}$$

Calculating a precise *SROI Coefficient,* however, is an imprecise process, as understanding the true value of impact and inputs requires assigning financial value to nonfinancial and sometimes intangible things. The range of methodologies used by firms globally to calculate the *SROI Coefficient* often compete on the basis of achieving appropriate specificity and accuracy in terms of calculating true value of impact.

Complicating methodology considerations further are the three typical applications and types of SROI evaluation.[10, 11]

1. **Forecast:** As the name suggests, this type of SROI analysis is conducted before the program or activity itself has been implemented in order to inform investment decisions. It is used as a predictive tool to determine the amount of social value that might be created by a particular initiative or effort.

2. **Evaluative:** This type of SROI analysis is conducted after a program or activity has already had time to affect change. It is used to understand effectiveness, communicate value and inform next steps (i.e. expanding a program).

3. **Theory of Change:** Theory of Change SROI evaluation explains a hypothesis about an impact activity. It outlines and proves causal linkages in an initiative (i.e., its shorter-term, intermediate, and longer-term outcomes). It is useful in determining causal links between specific initiatives and intended or unintended impacts.

A six-step process published by Social Value UK is widely considered the best practice foundation for comprehensive, accurate methodology. Their *Guide to Social Return on Investment* offers an in-depth overview for organizations looking to conduct SROI evaluation. Their process includes: [12]

1. **Establishing measurement scope and identifying stakeholders.**
    A scope is often the result of balancing data collection and measurement feasibility with the purpose or objective of the measurement activity. It is a decisive statement of the boundaries of measurement activity and will likely evolve over time as new information is gathered.

    Stakeholders are individuals, organizations or entities that are impacted and experience change as a result of the activity being measured. Their engagement will help identify types of anticipated and unanticipated impact that can then be included in comprehensive measurement.

2. **Mapping outcomes**
    This step involves visually depicting inputs, outputs, and outcomes. The process of developing the map includes engaging with stakeholders to identify types of change they have experienced and the specific mechanisms by which those changes have occurred.

    This step also involves valuing inputs. Generally, this is a straightforward process of calculating the cost of staff time, materials, technology, contracts, etc. The only two

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[10] Sopact, "How to Calculate SROI?", https://www.sopact.com/social-return-on-investments-sroi
[11] NEF Consulting, "Theory of Change", https://www.nefconsulting.com/our-services/evaluation-impact-assessment/prove-and-improve-toolkits/theory-of-change/
[12] Step titles quoted and descriptions paraphrased from: Social Value UK, *A Guide to Social Return on Investment 2012*, http://www.socialvalueuk.org/resource/a-guide-to-social-return-on-investment-2012/

nonfinancial inputs are volunteer time and gifts-in-kind, which are unlikely to be relevant in the context of a Smart Community project.

Outputs are the quantitative measure of activity and are also added. So are outcomes, which are more descriptive accounts of how various stakeholder groups have been affected.

3. **Evidencing outcomes and giving them a value**
Outcomes - as sourced from stakeholders - are often subjective and descriptive. Translating that into something measurable involves identifying indicators. Indicators are the answer to the question of 'how do you know that the change has happened.' Sometimes they are easy to identify and sometimes they require additional stakeholder involvement. Indicators must be checked against the scope and available resources. Indicator data is then be collected.

Simultaneously, outcomes must be given accurate valuation. Accurate valuation is essential to calculating SROI and often requires proprietary and/or entirely new research unique to each project and circumstance. Proxies can be used to simplify the valuation process.

4. **Establishing Impact**
Collected data is often general. A simple analysis of commute times before and after technology upgrades will not, on its own, prove that the technology caused any difference. Other factors must be calculated and removed. This is accomplished by calculating deadweight (what would have happened without the effort), attribution (what was caused by other efforts) and drop-off (how long an outcome lasts or doesn't last). Impact of the measured effort is then calculated by removing the quantitative measures of deadweight, attribution and drop-off.

5. **Calculating the SROI**
This is where all of the collected data and information is finally calculated into a single, cohesive SROI Coefficient for future use. Often, comprehensive calculations require expertise in future forecasting (including behavior forecasting), net present value and sensitivity analysis to arrive at an accurate figure.

6. **Reporting, Using and Embedding**
Results and insight must be shared with stakeholders. Disclosing and evaluating the measurement process (including any shortcomings caused by resource constraints or other factors) is important. Appropriate reporting ensures stakeholders will continue to contribute to further analysis.
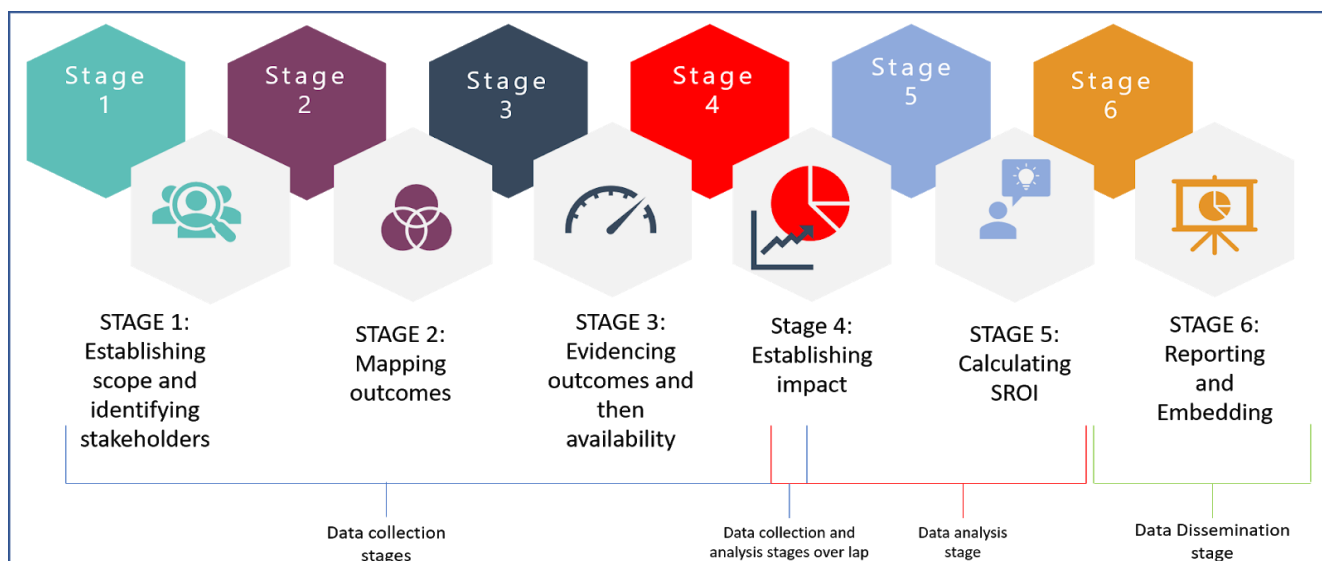
Figure 12 Visualization of Social Value UK process

Another publicly available methodology from the New Economics Foundation (NEF), an "independent think and do tank", condenses virtually the same general process into four steps: [13]

1. Boundary Setting and Impact Mapping
2. Data Collection
3. Modeling and Calculating
4. Report and Imbed

Another publicly available methodology and guide from Deloitte explores each step in more depth but effectively follows the same overarching process as Social Value UK and NEF.[14]

These methodologies can be applied to most – if not all – SROI measurement efforts. However, it is important to emphasize that, though they call themselves "methodologies", they require each project conduct a significant amount of "custom" work and activity. They are simply general procedures; the specific processes and formula for assigning values to different activities and calculating quantitative returns are unique to each circumstance, outcome and indicator.

To that extent, best practice SROI evaluation offers little opportunity for "one size fits all" approaches or tools. The best evaluations are customized on the basis of specific stakeholders, outputs, outcomes, indicators and other project parameters. There is a growing sector of consultants and contractors who have adopted or adapted the above-detailed general framework into evaluation services. Their experience successfully applying this methodology to a range of circumstances and completing numerous projects can add significant value over attempts to bring

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[13] New Economics Forum, *Measuring Value: a guide to Social Return on Investment,* https://commdev.org/pdf/publications/Measuring-Value-A-Guide-to-Social-Return-on-Investment.pdf
[14] Deloitte, *Is it Worth It? How to Measure Social Return on Investment*, https://www2.deloitte.com/content/dam/Deloitte/global/Documents/gx-is-it-worth-it.pdf

measurement in-house. Further, their sheer capacity to complete the amount of work required of a best practice evaluation is an additional benefit. In Colorado Springs, the Colorado Institute for Social Impact is one such organization offering fully "customized" SROI impact assessments.

However, not every organization or initiative has the resources to conduct a rigorous, "best practice" evaluation. Additionally, some types of impact are measured frequently enough that automated tools have been developed to calculate reasonable estimates of SROI for common activities. A range of Software as a Service (SaaS) solutions exist for these circumstances, where common inputs, outputs, indicators and data can be analyzed to reveal less-specific – but often still useful – SROI estimates. Some tools are only useful in specific geographies, others for types of projects. Still others are more customizeable, but often more expensive. Some examples include:

- LIIF, a community development financial institution in San Fransisco, offers a free tool for calculating the SROI of community development projects.[15]
- HACT, the UK's housing research agency, offers a free tool for assessing the SROI of housing projects in the UK.[16]
- Sopact, Social Value International, Sinzer, and a range of other software companies offer SaaS products for a fee.

Applying this insight to SmartCOS and efforts to measure SROI of City investment in technologies yields a general recommendation of conducting a unique SROI measurement effort for each of the 11 published SmartCOS initiatives. Since each initiative will affect a different, though possibly overlapping, group of stakeholders and achieve different, though again possibly overlapping, outcomes, the best way to ensure accurate assessment is a fully distinct process.

However, in recognition of budgetary constraints and relevant efforts of other municipalities, some preliminary SROI measurement can be conducted in order to inform City decision-making. This level of measurement is much more appropriate for forecasting than evaluative uses, though some evaluative insight might be possible.

To that extent, a preliminary tool has been developed and delivered alongside this document. Emphasizing the tool as "preliminary" is important: it is the product of 4 weeks' exploration and effort by a team of interdisciplinary undergraduate students.

Preliminary Model: Adapting the Fort Collins and Social Value UK Frameworks

The best, most accurate tools available – including one developed by the City of Fort Collins and provided to this effort by the City – required more than a year of dedicated staff time to build and

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[15] https://www.liifund.org/calculator-tool/
[16] https://www.hact.org.uk/about-us

calibrate. Considering that the constraints of this development effort made an entirely new tool of similar – or remotely comparable – sophistication and accuracy unlikely, the delivered tool is instead an adapted and combined version of similar, existing SROI measurement tools. Portions of City of Fort Collins tool were directly adopted into the delivered tool considering their anticipated efficacy, as were components of a publicly-available tool from Social Value UK.[17] Developing a tool of sophistication and accuracy equal to either model and specific to Colorado Springs is important. It will require significant, focused work in the future.

The intention of the attached preliminary tool is to provide some insight into comparative value. As mentioned, it includes portions of the Social Value UK and Fort Collins tools. By linking their respective value in a single Microsoft Excel spreadsheet, the delivered tool provides a more comprehensive snapshot and ease of use than either tool on its own.

Sample data was applied to the compiled tools to understand how each tool performs and potential relevance to Colorado Springs. Some adaptations were made to increase relevancy and applicability to Colorado Springs, though more intentional revising is required to make this a tool fit for the Office of Innovation's needs. With limited time to make such comprehensive adaptations, shortcomings and needs for further changes are highlighted in subsequent, tab-specific sub-sections sections.

Ultimately, this tool should still provide needed value to the City. Many of the components most significantly out of line with City needs can be left blank or "neutral" to effectively zero out their impact on calculations and results. Additionally, some other, minor, project-specific changes can be made in real time to bring the tool into closer alignment with each use case.

Purpose: 11 SmartCOS Initiatives and Beyond

The City's immediate priority is understanding likely SROI for the 11 currently identified SmartCOS Initiatives in order to inform appropriate prioritization of work between and within initiatives.[18] The City's Office of Innovation has identified the need for a forecast SROI framework to support this work.

In addition to the Social Value UK and Fort Collins models previously mentioned, information and components from the *Bern Sustainability Compass,*[19] OECD,[20] and other sources previously mentioned[21] were used in the development of this preliminary framework.

As a general framework, further customization of fields and parameters is required for the tool to work for any specific initiative in Colorado Springs. However, the structure, formulas and

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[17] Social Value UK Value Map download: http://www.socialvalueuk.org/resource/blank-value-map/
[18] Initiatives listed here: https://coloradosprings.gov/smartcos
[19] Interdepartmental Sustainable Development Committee, *Sustainable Development in Switzerland: A Guide*, https://www.are.admin.ch/dam/are/en/dokumente/nachhaltige_entwicklung/publikationen/nachhaltige_entwicklunginderschweizeinwegweiser.pdf.download.pdf/sustainable_developmentinswitzerlandaguide.pdf
[20] OECD, *Guidance on Sustainability Impact Assessment*, https://www.oecd.org/about/publishing/47442744.pdf
[21] Including Sopact, NEF and Deloitte.

overarching tool should yield preliminary insight sufficient for the City's purposes. To further support the City's use of this tool, some potential indicators, parameters, and adaptations for each of the 11 SmartCOS initiatives are proposed at the end of this report (p. 18).

Development Process and Key Considerations

As detailed in the best practices above, the first step of an SROI evaluation is to define a scope and identify stakeholders. Initially, development efforts were focused on developing a new or highly original tool for only a single SmartCOS effort. However, stakeholder groups for each initiative are still rapidly evolving, making a short and concise engagement process difficult. In consideration of the limited timeframe for tool development (4 weeks), development pivoted to compiling a more general framework that the City could then adapt as necessary to each specific initiative.

To that extent, the tool needed to accommodate many potential stakeholders, many potential outcomes, many potentially different types of data and consideration of many unique, project-specific factors that may not be valuable when considering any other project. Identifying, adapting and compiling existing tools to expedite future efforts by the City to forecast SROI was deemed to be more valuable.

Chief among considerations in this work became identifying existing tools that could be adapted for City work. The City provided the Fort Collins model as a very strong example, and also facilitated communication with the individuals responsible for its development. The City also referenced Social Value UK as another strong example. That is why components of both tools are so heavily present in the delivered framework.

Tab 1: Contents + Sources

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This sheet is simply a set of shortcuts to the other sheets in the file to simply navigation. A short description of each linked-sheet is also provided. The sheet itself is only slightly adapted from the Social Value UK tool.

Tab 2: Guidance

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This sheet, included directly from the Social Value UK model with no changes, has been included in order to provide instruction and further resources for how to use and adapt the tool. The content directly references and makes applicable information related to the SROI best practices detailed above.

Considering the alignment of this component with City needs, general rigor of the source material, and importance of the information and externally-linked resources in SROI measurement work, little original work from this effort was likely to yield additional value.

Tab 3: Scope

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This sheet, an unchanged component of the Social Value UK model, offers a rigorous structure for establishing the scope of any subsequent measurement effort. It represents the first real "work step" in using the model.

Figure 13 - Social Value UK Value Map

Sample information from one of the City's projects has been included in the Excel file as an example of how to use the tool. The fields with no background should be erased and filled with information appropriate to each project for which this tool will be used. The cells with a solid-color background should not be changed.

The inclusion of this component verbatim from the Social Value UK tool was again the result of evaluation highlighting its comparative value to the City's goals as-is. It is already fully customizable and publicly available, so little additional work was needed to make it suitable for City use.

Tab 4: SROI Value Map

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

Figure 14 - Social Value UK SROI Value Map

This sheet, an unchanged component of the Social Value UK model, offers a rigorous framework for capturing information from stakeholders regarding inputs, outputs, outcomes, indicators and types of data. It is directly consistent with the above-detailed best practices and should be used to visually capture mechanisms of change and measurement in monetized terms. It includes formulas to calculate a range of key information like net present value and SROI ratio (further detailed in Tab 2). The information this tab will ultimately contain will inform use and further adaptation of subsequent sheets for the unique parameters of specific projects.

If information is not available in monetized terms, this tab should not be used. Instead, Tab 5 should be used to serve the same purpose.

The inclusion of this component verbatim from the Social Value UK tool was again the result of evaluation highlighting its comparative value to the City's goals as-is. It is already fully customizable and publicly available, so little additional work was needed to make it suitable for City use.

Tab 5: Value Map (Non-SROI)

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This sheet, an unchanged component of the Social Value UK model, offers a rigorous framework for capturing information from stakeholders regarding inputs, outputs, outcomes, indicators and types of data when monetized information is not available. Like Tab 4, it is directly consistent with the previously-detailed best practices and should be used to visually capture mechanisms of change and measurement in non-monetized terms. It does not have any formulas for calculating various financial and quantitative implications of the information. The information this tab will ultimately contain will inform use and further adaptation of subsequent sheets for the unique parameters of specific projects.

If information has been appropriately valued and monetized, this tab should not be used. Instead, Tab 4 should be used to serve the same purpose.

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Like Tab 4, the inclusion of this component verbatim from the Social Value UK tool was again the result of evaluation highlighting its comparative value to the City's goals as-is. It is already fully customizable and publicly available, so little additional work was needed to make it suitable for City use.

Tab 6: Glossary

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This sheet provides a definition of terms in the previous two tabs. It is also an unchanged component of the Social Value UK model, utilized to ensure consistency with the other unchanged Social Value UK components.

Tab 7: TBS (Input)

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

If insight into the forecast economic, environmental or social impact of a project is relevant to the specific project being measured, the Triple Bottom Line scan methodology from the City of Fort Collins has been included unchanged in the provided tool.

This tab should be used to capture anticipated impacts and other components of the project. It offers a limited set of editable inputs that can be changed considering the specific project parameters. Completing the previous sheets from the Social Value UK tool is an important step towards understanding and gaining confidence in answering the specific input fields.

Of note, some of the rows in this model are not applicable to Colorado Springs. They represent specific priorities, goals or commitments that the City of Fort Collins has confirmed, distinct from Colorado Springs. These areas include:
- Row 8 refers to Climate Action goals. The City has not finalized Climate action goals. Using "neutral" should accommodate.
- Row 34 refers to growth in "climate economy." The City has not determined this to be a priority sector. Using "neutral" should accommodate.
- Row 48 refers to a specific definition of Affordable Housing. The City's comprehensive housing plan, HomeCOS, identifies different definitions and categories of housing. Using "neutral" will eliminate this category from consideration, but does not fix the misalignment as the City has made specific goals in affordable housing.

Other information, like row 9 (climate change resilience and natural disaster preparedness) are only partially relevant. The City has published goals related to national disaster resilience, but not climate change. Additionally, much of the economic health information does not reference City priorities or economic sectors of significance (like cybersecurity). This illustrates the fundamental challenge of adapting this model: much of the language and specific calculations have been finely calibrated and weighted in accordance with Fort Collins goals and priorities.

The nuanced changes to bring this work into alignment with the City's priorities will require significant time and resources, exceeding the capacity of this student effort.

These weaknesses aside, it is important to emphasize that the Fort Collins-specific parameters still offer significant value to the City in terms of forecasting how a project will perform. The differences between the Fort Collins parameters and the City's parameters are nuanced. The outputs still give a general sense of the extent of positive or negative impact in the three focus areas, which is very useful in SmartCOS development work.

Tab 8: TBS (Output)

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This tab visualizes the results of calculations performed on the input information in Tab 7. The formulas and calculations have not been changed from the Fort Collins-provided model because of the time required to make such nuanced and finely-detailed changes previously discussed.
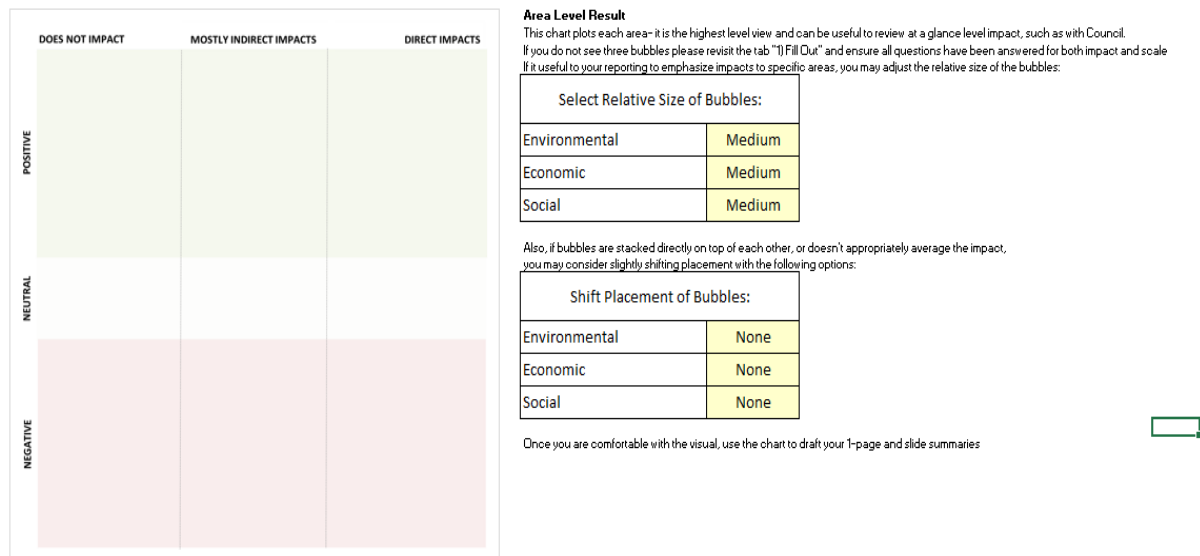
Figure 15 - Fort Collins Triple Bottom Line Scan Output Tab

Importantly, this tab offers a mechanism for accounting for the differences between Fort Collins and City priorities. By adjusting the size of the visualized bubble for each type of impact, a visual "weighting" is possible. Increasing the size of the economic health bubble to large is likely appropriate for the City, as is allowing the Social and Environment bubbles to stay medium.

Tab 9: Dimensions of Impact

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This tab is an amalgamation of information from the Ft. Collins model, OECD resources and some new, Colorado Springs-specific parameters. By inputting specific information in column C/D (input fields are merged), quantitative estimations of impact are calculated in column G, specific to each dimension of impact. Sample information about the Telematics project has been included in the sheet to illustrate use. Information in corresponding cells should be deleted and replaced with appropriate information for the specific projects using this tool.

Instead of asking for qualitative positive/neutral/negative inputs, this tab asks for quantitative values between -2 and 2 in increments of 0.2. -2 represents "very negative", 0 represents "neutral", and 2 represents "very positive". This allows for greater specificity of input and output information to refine the tools use in decision-making. In theory, these cells could be linked to a real time analytics platform to yield evaluative insight in addition to forecast.

6	Externalities	Obstructs Initiative	Promotes Initiative	Mean Score
SROI 1	Has this project been reviewed by a panel of people?		1.80	0.43
SROI 2	Has this project been tried in another city?		2.00	
SROI 3			-1.20	
7	Cyber-security	Obstructs Initiative	Promotes Initiative	Mean Score
CYBERSECURITY CERTIFICATIONS				0.67
CS 1	GDPR Certification		2.00	
CS 2	CMMC Certification		2.00	
CS 3	NIST Certification		0.00	
ZERO THREAT SECURITY MODEL				
CS 4	Initiative follows an organizational zero-threat I.T infrastructure		0.00	
CS 5	Enhances the cybersecurity meta by aligning with NCC (or other institution) standards		0.00	
	Mean Scores			Overal Score
				4.09

(bar chart values: 1, 0.75; 2, 1.00; 3, 0.40; 4, 0.38; 5, 0.46; 6, 0.43; 7, 0.67)

Figure 16 - Sample Outputs

The dimension model standardizes each of its calculations to a unit per dimension. In other words, the current tool contains 7 dimensions. It therefore generates a **total score out of 7 in cell G72**. This refers to the mean score under each dimension, calculated as such:

$$\frac{\sum_{0}^{n} Target\ Scores}{Number\ of\ Target\ x\ Max\ Score}$$

In theory, if a project is achieving all targets in a particular dimension, the mean score would be 1, if a project is achieving all targets in 7 dimensions, it has a perfect score of 7/7.

In addition to a quantitative score, a bar chart is generated at the bottom of the sheet to facilitate a better overview of the dimensions and how a project fairs. The score is a forecast and must be manually inputted in the project ranking dashboard in the subsequent Overview ROI Calculator

tab. It's important to note that a negative mean score will show as blank in this graph but will affect the scoring arithmetic.

The first impact dimension is the Baseline SmartCOS initiatives. A project serving multiple concepts will score better; however, the increased range of inputs allows the extent to which a project serves a concept to be weighted appropriately.

The Cost of Partnership Dimension uses the Fort Collins approach to economic impact but attempts to rectify some of the misalignment detailed above. The parameters value investment in Opportunity Zones, for example, a specific priority of the City's Economic Development division.

Note: The general negative/positive framework should still be used in this dimensions. So a "negative" parameter (like eliminating jobs) should receive a negative quantitative score.

The Economic Development dimension considers the ultimate result of economic impact. Instead of typical economic indicators like jobs or income, it assesses how those then translate to lived experience for the community. Considering the highly subjective nature of much of this kind of information, the social impact components of the Fort Collins model were used as a stand in. As previously mentioned, though, those parameters are not perfectly aligned with City goals. The use of simple "mean" calculations means these specific types of impact – and types of impact considered under other dimensions – can be easily substituted with other values with no major disruption to the mathematical accuracy. Should traditional economic indicators be more useful to the City, the current parameters can simply be replaced.

The Sustainability Dimension considers the longevity of impact of a specific project. It does not currently assess other types of sustainability, like financial or environmental. Should those be desirable to the City, they can be added so long as the corresponding formula in cell G43 is adjusted accordingly.

The Delivery of Citizen Services considers various ways in which a project might perform against the City's general goal of improving citizen service delivery. Like previously discussed dimensions, the contained parameters represent considerations deemed appropriate and valuable by the undergraduate student team leading this effort. They may or may not match a nuanced, in-depth assessment of how the City considers the efficacy and impact of service delivery. They, too, can be changed to better reflect City priorities and perspectives as needed.

The Externalities Dimension considers only two factors that are useful in City decision making. In a way, it can be thought of as a "tie breaker" between risky, unproven projects and more established ones as is.

However, this dimension is specifically intended to be expanded. Recommendations from the Colorado Institute for Social Impact (CI4SI) are to expand this section to include a variety of unconventional and possibly hard to measure components like reduced stress levels, response time impact for firefighters/police officers, commute times and many other project-specific outcomes that are valuable to consider. The idea for the targets used in this model are to be

intentionally left open-ended. Though no two projects will include the same parameters in this section, this approach allows for separate types of impact to still be compared, at least to an extent.

The Cybersecurity Dimension considers parameters specific to the recommendations in the separately delivered report *2. Building Smart Communities Partnerships* that was part of this same research effort from the Quad. It is intended to measure and value the security of various network and data components.

Tab 10: Overview ROI Calculatior

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

This tab is meant to visually compare the performance of 5 projects (Tabs 11 through 15). The specific score from individual analyses using the Tab 9 Dimensions of Impact tool must be manually entered for each project. Other information should populate automatically, based on information provided in the subsequent tabs. This format and formulas are pulled from based on a template from SmartSheets.

Tabs 11-15: Project Tabs

This section provides an explanation of the correspondingly-named tab in the provided Microsoft Excel tool.

These tabs are intended to store information for specific projects for calculation in Tab 10. Some of the information – like types of impact and associated valuations - can be developed using other tabs in the provided Excel tool (specifically, the Social Value UK value maps). Some of the necessary calculations, though, fall into the "custom build" area of SROI analysis discussed towards the beginning of this document.

These sheets are based on a SmartSheets template.

Appendix: Potential Indicators for SmartCOS Use Cases

Smart City Technology:	Indexes:	Explanation:	Proposed method of tying it back to value	Intended Result:
Smart Security systems	Improved security data → improved safety and security strength, increased ownership over personal security,	Higher technological security systems will provide reliable, safer security, as well as quantifiable data on security measures	Data from security systems can reflect statistics on the frequency and types of security breaches, which informs what measures need to be taken to make things more secure → less security issues (dependent on the issues identified)	Increase security efficiency and effectiveness, increase safety and provide working knowledge on how to improve security systems/measures (dependent on the issues identified)
Smart Street Lights	Safety, reduced traffic congestion, reduced energy costs, reduce emergency response times	Streetlights are the base for a smart camera and data collection system. This is where smart city Technology can be seen directly by the public	Saved time of the city workers who manage traffic-related incidents, less accidents and incidents leading to saved money, increased overall experience of driving in Colorado Springs	Safer, more secure neighborhoods with reduced traffic congestion and better efficiency of city resources.
Connected Vehicle Platform	Safety, reduced traffic congestion, reduced energy costs, reduce emergency response times	These platforms allow vehicles to communicate and therefore become more efficient, and safer.	Reduced traffic congestion, increased tourism, increased transportation efficiency. Reduced carbon emissions	This platform gives various results, more efficient routes. Increased senior engagement. Pilot data
Microgrids	Carbon emissions. Energy reduction. Resilience.	Potential reduction in carbon emissions and energy costs	Reduced environmental tole, increased economic development, reduced carbon emissions	Extrapolating dollars saved per household in energy bills.
Enhanced Engagement	Increase the delivery of citizen services. Increased Localized awareness	Increase the citizen engagement, increase city to citizen communication	Increased citizen satisfaction and happiness, increased city engagement, increased economic growth	Giving the citizens more opportunities to engage through the city
Smart Building Management System	Reduced energy costs, risk management, prioritize improvements, greater employee	AI technology integrated into a building. It can predict maintenance needs, thermostat	Improved experience for building occupiers, increased savings on electricity and heating bills, increased	Reduced energy costs, risk management, prioritize improvements, greater employee

	engagement, employee comfort.	controls are auto mated to the use of the space and not pre-programmed, reducing operational costs.	functionality of the building	engagement, employee comfort.
Smart Kiosks	Convenience, Versatility, WiFi speed and signal, Information management, Security,	A one stop shop. Pay for parking, fines, utilities, get information about bus routes, report a crime, report a city problem.	Payment choices, reduce late fees, streamline merchant processing, Increasing citizen engagement.	Provide tourists with information. Provide citizens with an easier way to complete tasks associated with the city. Enhancing experiences for all users.
Smart Parking	Lower stress levels, less distance to destination, time savings, money savings, ease traffic congestion,	Applications that allow a user to find, pay for, and even extend paid parking. From the city side it would reduce staff needed to check meters as the tickets would auto generate.	Payment choices, reduce late fees, streamline merchant processing, Reduce contact.	Optimized performance, increased productivity, and reduced delivery times for the people working in this sector.
Smart Payment Solutions	Payment choices, reduce late fees, streamline merchant processing,	A streamlined and more efficient way to make payments	Payment choices, reduce late fees, streamline merchant processing,	Optimize the process of having to make payments
Smart Transportation	Increased commute efficiency, decreased traffic (cars), decreased pollution, increase intercity relations/community, data on the movement of citizens	Having more efficient and available modes of public transportation (possibly to and from Denver – Colorado Springs) to help citizens travel more efficiently	Data could reflect the commuting patterns of citizens, better public transportation options means less carbon emission coming from personal vehicles, data from smart streetlights could provide insight on traffic patterns before/after smart transportation is implemented	Increase efficiency for public transportation, ultimately impacting carbon emissions and street traffic (especially during rush hours)